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THE DIFFERENTIAL ANALYSIS OF STARCHES

BY

JAMES B. MCNAIR

ASSISTANT CURATOR OF ECONOMIC BOTANY

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ACTING CURATOR, DEPARTMENT OF BOTANY

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CHICAGO, U. S. A.

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THE DIFFERENTIAL ANALYSIS OF STARCHES

James B. McNair

INTRODUCTION

Reichert, in his excellent and extensive monograph on starch, gives a historical review dealing with the starch substance, the primary and reverted decomposition products of starch, and the structure, form and mechanism of formation of the starch grain. He outlines the chief forms and classifications of starch grains and has determined in painstaking detail histological, chemical and physical characteristics of 350 starches. For each of these he gives two photomicrographs showing their appearance in ordinary and polarized light.

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Extensive tables of the various histological, physical and chemical characteristics are included in Reichert's work. These tables, as they stand, arranged in botanical order, are of limited usefulness to the analytical chemist. For his own convenience the author has rearranged them according to physical and chemical properties and it is thought that thus rearranged they will be found of interest and utility to all who have occasion to deal with starches in an analytical way.

It is sometimes of importance to be able to determine the botanical source from which a certain starch sample is derived. This task, formerly never attempted, is now possible because of Reichert's work. It has become possible not only to tell the difference between starches of different plant families, as corn starch from potato starch, but also to determine between the starches of the members of one family of plants as in the case of wheat, rye and barley; or even to tell whether the starch has come from different varieties of one species—for example, the starch of ginger root from Jamaica, and of ginger root from Cochin China, or between the starches of pod corn, pop corn, flint corn, dent corn, soft corn, sweet corn, and starchy-sweet corn.

Some of these differential determinations may be made by the appearance of the starch grains under the microscope. In some cases chemical analysis will also aid, when, for instance, the percentage of hemicellulose varies between different species as was shown by Ling and Nanji[1] or when the ash is not the same either qualitatively or quantitatively as has been found to be the case in many instances, or when the phosphoric acid present in organic combination varies in different starches, or when the combined fatty acid varies in quantity or quality between the starches.[2] No

[1] Arthur R. Ling and Dinshaw R. Nanji, Chemical Society of London, *Journal*, CXXIII (1923), 2666–88.

[2] T. Clinton Taylor and John M. Nelson, American Chemical Society, *Journal*, XLII (Easton, 1920), 1726–38.

doubt the physical properties of starches, such as their qualities of viscosity and water absorption, can also be used in their differentiation.

The investigations of Reichert[3] have given us methods which will differentiate between the various starches in a minimum of time with a minimum of materials.

Reichert was able to differentiate between 350 different starches by means of eleven processes of analysis, namely: (1) histological microscopic examination to determine the form and size of the grains, position and character of the hila, characteristics of the lamellae, orientation, etc.; (2) the degree of polarization; (3) the iodine reaction; (4) the gentian violet reaction; (5) the safranin reaction; (6) the temperature of gelatinization; (7) the chloral hydrate-iodine reaction; (8) the chromic acid reaction; (9) the pyrogallic acid reaction; (10) the ferric chloride reaction; and (11) the Purdy solution reaction.

These tests are carried out on small amounts of material by the aid of microscope and require individually not more than one hour's time. Reichert's processes of analysis are summarized at the end of this paper.

PREPARATION OF THE SPECIMEN OF STARCH

Starch, as is well known, constitutes reserve food for the plant and is stored in the leaves, stems, and roots.

Reichert's plant specimens were tubers, rhizomes, bulbs, corms, stalks, fruit, pseudo-tubers, seeds, and in most cases underground parts. A specimen was comminuted by the aid of an ordinary kitchen grater, nutmeg grater, sandpaper, or small drug mill, in accordance with the quantity and physical characters of the specimen. Four or five volumes of water were added to the ground specimen, the mixture thoroughly stirred, the mass strained through four thicknesses of cheesecloth, and the pulp then washed with sufficient water and strained as before. The starch-water preparation is decanted in cylinders and the starch is cleansed by repeated washing and decantation. Finally the starch is collected in shallow dishes, the water as far as possible drained off and the preparation dried at a temperature of 50° C. By this simple means starches can be prepared, which are with rare exceptions practically free from gross impurities; that is, as pure as the nature of Reichert's investigations demanded.

HISTOLOGICAL METHOD

Magnifications ranging from 85 to 400, sometimes higher, are used, according to the size of the grains and incidental conditions. A sufficient amount of dried starch is placed on a slide and mounted in a very dilute Lugol's solution, care being taken not to add a larger quantity of iodine than is sufficient to accentuate the lamellae. Since starches of different sources show wide differences in the intensity with which they become colored with iodine it is found convenient to

[3] Edward Tyson Reichert, *The Differentiation and Specificity of Starch in Relation to Genera, Species, etc.*, Carnegie Institution of Washington, Publication No. 173, Washington, D.C., 1913; *A Biochemic Basis for the Study of Problems of Taxonomy, Heredity, Evolution, etc.*, Carnegie Institution of Washington, Publication No. 270, Washington, D.C., 1919.

have on hand a number of solutions ranging from 1 to 2 per cent down. By the aid of such ordinary microscope technique there are recorded the form and size of the grain; the position and form of the hilum, or the assumed point of origin of growth or center of organic structure; the form, number and other characteristics of the lamellae; the characteristics pertaining to the form of the grains, whether singly or in doublets, triplets, or aggregates, etc. In describing the grains the terms "proximal end" and "distal end" have been adopted, the former being the end nearer which the hilum is located. The "longitudinal axis" corresponds with an imaginary line, extending from the proximal end through the hilum to the distal end. In different starches and in different grains of the same kind of starch this may be the long or the short axis. The measurements of eccentricity of the hilum have reference to the distance of the hilum from the proximal end of the longitudinal axis.

REACTIONS IN POLARIZED LIGHT WITHOUT AND WITH SELENITE

Starches have been found to exhibit not only marked differences in the degrees with which they rotate the plane of polarized light, but also differences in the characteristics of the "interference figure" or "cross," as it is generally termed. The general characteristics, distinctness, shape, regularity, and position of the interference figure, and also the approximate degree of anisotropy or intensity of polarization were readily studied. By the aid of selenite it was determined whether the optical properties were negative or positive, and also the size, shape and regularity of the quadrants, as well as the intensity and pureness of the blue and yellow colors. In spherical grains with centrally located hila, the two parts of the "cross" intersect at the hilum, or mathematic center, of the grain, so that the term quadrant has a proper application; but in the case of grains having eccentric hila the position of the point of intersection of the two parts of the cross, together with their curvatures, may destroy every semblance of quadrants according to the conventional definition of this word. This term has therefore been used in a very broad sense throughout Reichert's investigation to indicate the four parts of the grain that are defined by the two parts of the cross, in preference to the great multiplicity of terms that would be required to define these parts if great accuracy were attempted. Likewise, for convenience the term "lines" of the interference figure may be used in preference to the "arms" of the cross.

All starches are "optically negative," hence no special references have been made in the text in this particular.[1]

The slides for polariscopic examination are prepared as follows: The end of a small spatula is thrust into the specimen of starch and moved about, withdrawn and sharply tapped several times in the center of the slide, and the slide jarred in a manner to cause a practically uniform distribution of the starch grains in a single well-disseminated layer. The margins of this layer are carefully removed so as to leave an area 12 mm. square. An expeditious way of removing the margin so as to insure a uniform area of starch is to use as a wiper a piece of sheet celluloid having a 12 mm. slot, wiping transversely and then longitudinally. A few drops of balsam are carefully added at the center of the area, a cover-slip put on, and the slide placed on the stage of the polarizing microscope. After determining the degree of polarization, the selenite plate is introduced and the specimen again examined.

In order to reduce the degree of polarization into values in comparative terms and figures it was found desirable to adopt an arbitrary scale and to select three

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In order to reduce the degree of polarization into values in comparative terms and figures it was found desirable to adopt an arbitrary scale and to select three

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starches as standards that give wide and properly separated gradations of value. Thus, adopting a scale of 100 divided primarily into units of 5, the starch of *Solanum tuberosum* was taken as having a value of 90 and "very high"; that of *Narcissus poeticus ornatus* as having a value of 50, or "moderate"; and that of *Richardia albo-maculata* as having a value of 30, or "low." Intermediate gradations are readily expressed by both words and figures. If the starch examined has, for instance, the same degree of polarization as that of *Narcissus poeticus ornatus* it is given a value of moderate or 50, but if its value be between moderate (50) and high (70) it is recorded as being moderately high (60), or moderate to moderately high (55), or moderately high to high (65). In some instances intermediate values are given where it is necessary to express smaller differences, as between members of a set consisting of parents and hybrid. The different grains of any given specimen of starch vary in the degree of polarization, so that in rating the average must be estimated; as a consequence all of the records are averages. The method is of a very gross character and the personal equation in determining values may be very important and lead to more or less divergent records by different observers, but in practice it has been found that after a degree of skill has been acquired, as common in all such gross methods of experiment, essentially or absolutely the same values are recorded when experiments are repeated several times at well-separated intervals, or made by two individuals who have had practically the same training. Owing to variations in illumination from time to time, it is quite important to use persistently, in conjunction with the starch to be examined, some starch that has been adopted as the standard of comparison, preferably one that has a close value. Thus, when studying the starches of a group, one of the starches is standardized with the starch standard and scale adopted, as before stated, the standard recorded for this starch serving as the fundamental standard for comparison for the others of the group. This method gives very good comparative results, especially when the group consists of a few members; but it is, on the whole, the least valuable of all the methods employed in this research, and its usefulness is chiefly because of its remoteness from the characters of the other methods.

IODINE REACTIONS

The use of iodine not only serves to bring out certain histological peculiarities, but also valuable data in the differentiation of different kinds of starch. The typical or ordinarily observed reaction of starch with iodine is an indigo-blue, but if an excess of iodine be avoided the reaction of the grains will be found to vary usually from a blue to reddish-violet, including within these extremes all shades of violet from a purple to a reddish-violet according to the kind of starch. In fact, in the presence of minute quantities of iodine, starches are colored some shade of violet, varying with the kind of starch. With any quantity of iodine certain starch grains yield a red reaction. In studying the iodine reactions we used 0.125, 0.25, and 2 per cent Lugol's solution. Four serial reactions were studied, two with raw starch and two with gelatinized starch. In the first two, the slides are prepared as in the polarization examinations, substituting solutions of iodine for the balsam and examining the slides in ordinary light with a fully open diaphragm and low power. In the first reaction two drops of 0.25 per cent Lugol's solution are placed on the starch, the slide quickly adjusted on the stage of the microscope, and the color reaction in quality and quantity at once determined, the quantitative value recorded being taken as the standard of comparison in relation to other starches. Here, as in the polarization determinations, it was found necessary to adopt an arbitrary scale and starch standards. The same scale is used as for the polarization values, but the terms "light," "deep," etc., were substituted for "low," "high," etc. Moreover, it was found necessary to modify the selection of starches to be used as standards. The starch of *Solanum*

tuberosum was taken as having a value of 60 or "moderately deep," that of *Crinum Moorei* as having a value of 30 or "light," with corresponding intermediate figures and terms as in the polariscopic determinations.

ANILINE REACTIONS

Aniline colors in solution, especially when in weak solution and exposed to light, are notably unstable, and in order to secure strictly comparable results a quantity of a relatively strong standard solution was prepared and kept in the dark, tightly corked. The stock solutions were composed of 0.25 gm. of aniline with 150 cc. of distilled water. From day to day dilute solutions were prepared by adding 33 cc. of water to 2 cc. of the stock solution; 15 cc. of the latter solution were placed in a test tube containing 0.07 gm. of starch, the preparation agitated, 1 or 2 drops withdrawn in a minute and examined under the microscope, and a final examination made at the end of half an hour. In these color determinations the microscope was used, as in the iodine reactions, with a fully open diaphragm and low power. Owing to the relatively slow reaction, the values for comparative purposes were taken at the end of half an hour instead of immediately, as in the first iodine reaction. The method of valuation is the same as in the iodine reactions, but the starch standards for these reactions are: *Solanum tuberosum*, value 90, "very deep"; *Amaryllis belladonna*, value 50, "moderate"; *Freesia refracta alba*, value 30, "light."

TEMPERATURES OF GELATINIZATION[1]

A long quadrangular water bath is used, holding about 4 l. of water; one end is placed over the gas flame, and in the other end is inserted a thermometer which is calibrated in tenths centigrade, but which could readily be read in hundredths. A small quantity of starch with 10 cc. of water is placed in a test tube, into which is inserted, through a perforated cork, a thermometer similar to the one in the water bath, and the test tube immersed in a suspended wire basket in the part of the water bath farthest from the flame. The temperature of the water is raised very slowly, and the water occasionally stirred, so that at no time should the two thermometers differ more than about 2°. As the temperature increases, specimens of the starch are examined at intervals, the tube being shaken, and a specimen obtained by inserting the end of the pipette to the bottom of the tube, a clean pipette being used to remove each specimen. Each specimen is placed on a slide, upon which is recorded both temperatures, and the slide is examined in the *polarizing microscope*. The temperatures at which there is an entire loss of anisotropy of a majority and of all of the grains are recorded as the temperatures of the tube. The lower temperature recorded on the slide is the record of the thermometer in the test tube, and the higher temperature is that of the water bath. The actual temperature of gelatinization lies somewhere between the two, and for convenience, especially for purposes of comparison, the mean of the two was for obvious reasons taken as the "temperature of gelatinization." In the records all three temperatures are given in accordance with the foregoing.

ACTION OF SWELLING REAGENTS

Five such reagents were selected. The choice was made of those which differ widely in chemical composition and yield sufficiently prompt and characteristic

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[1]It seems probable that another method could be devised in which much smaller amounts of starch could be used. C. W. Mason sends the following reference for the determination of melting points by the aid of the microscope: E. M. Chamot, *Chemical Microscopy*, 1921, chap. ix. Ralph T. K. Cornwell contributes these citations: publications of the United States Bureau of Mines; American Chemical Society, *Journal*, XXXIV (1912), 954, 1,328, XXXIX (1927), 742; and Houben-Weyl, *Die Methoden der organische Chemie*, Erster Band, S. 731 (Zweite Auflage).

results. They are: chloral hydrate-iodine, pyrogallic acid, chromic acid, ferric chloride, and Purdy's solution.

The chloral hydrate-iodine solution is prepared by saturating a saturated solution of chloral hydrate with iodine. The solution, sooner or later, not only causes swelling and ultimate partial dissolution of the grains, but also, owing to the presence of iodine, yields important accompanying color reactions; and it is on the whole to be regarded as a very valuable reagent. Chromic acid is used in the form of a 25 per cent solution, and it is the only one of the five reagents that causes within the periods of observation a complete disintegration of the grains. It gives rise to gas bubbles during the decomposition processes. The pyrogallic acid solution is prepared by making a saturated solution and diluting this with three parts of water, adding oxalic acid in the proportion of 4 per cent to prevent oxidation. The ferric chloride solution consists of equal parts of a saturated solution and water. Purdy's solution is made of equal volumes of the standard solution and water.

Purdy's solution is the least active of the five, and it is, so far as the effect on the grains is concerned, probably essentially an aqueous solution of KOH, and therefore likely possesses no advantages, except perhaps in keeping qualities, over the simple aqueous solution.

Oxygen or exposure to the air favors the action of pyrogallic acid, but hinders those of chloral hydrate and ferric chloride. In the former case the grains near the edge or on the outside of the cover-slip are decidedly more affected than those within, while in the latter the opposite is true.

There are some forms of commercial chloral hydrate that have very little action. The crystals put up by Schering were used throughout Reichert's work.

It is important that fresh solutions of the reagents be prepared at short intervals, as all tend to deteriorate, and it is well to let them stand over night before using.

In using these reagents a small amount of starch is placed on a slide, several drops of the reagent added, a cover glass put on, and the progress of events examined under the microscope. In using a given reagent with a given kind of starch, it was found that there occurred a certain amount of variation in the effects from time to time, which are probably to be attributed chiefly to variations in temperature, so that these studies were made as far as possible under constant temperature conditions.

The variations as a rule were unimportant. These agents give rise to gelatinization and swelling of the grain, and cause the existence of the outer and inner parts of the grains to become very conspicuous—the outer part becoming sac-like and inclosing a less dense or semifluid substance.

In the reactions with the chemical reagents it is essential, in order to obtain uniform and wholly reliable results, that the slides should be prepared with much care as regards the quantity and distribution of the starch and the quantity of the reagent, and that immediately upon the addition of the reagent the preparation be protected so that changes due to alterations in concentration and to oxidation will not occur. The method pursued is as follows:

A square area of starch is first prepared on a slide as in the polarization reactions. This square is surrounded by a layer of purified vaseline 5 mm. wide, applied by an artist's flat camel's hair brush. A cover-slip is now prepared by coating the margin of one surface with a corresponding band of vaseline, so that when the cover-slip is placed on the slide the surfaces of two vaseline squares form an air-tight junction, preventing change in concentration of the reagent by evaporation or absorption of water and eliminating the influence of the oxygen in the atmosphere. Two drops of the reagent are carefully and quickly placed on the center of the starch layer, the cover-slip instantly applied, the slide placed on the stage of the *polarizing microscope*, a suitable field speedily found and

examined in polarized light. Usually a practically exact count is made of the number of grains in view, but if the reaction is very rapid this part of the method is modified as hereinafter stated. All these procedures are done as expeditiously as possible. In the starches of some species there are to be found variable proportions of very minute grains which for obvious reasons must be ignored in making the count. The number of grains in the field ranges usually from 150 to 200, rarely as few as 75 to 100 or as many as 400 to 600, the number depending largely upon and in approximate ratio to the mean size of the grains; but such differences in number do not imply corresponding differences in the total amount of starch present. In specimens in which the grains are small, the number of grains in the field will be larger than when the grains are large, and the number will vary also because of some irregularities in the distribution of the grains, a field always being selected that is well adapted for the count and for watching the processes of gelatinization. Unless gelatinization occurs very rapidly the percentages of grains and total starch gelatinized are not determined until at the end of 5 minutes from the time of the addition of the reagent, and subsequently at 15-, 30-, 45- and 60-minute intervals, or as may be desirable. At these periods the number of grains not completely gelatinized is counted, and then the percentage of grains completely gelatinized is computed by finding the difference between the original number in the field and the number thus found. In addition to the grains completely gelatinized there will be seen grains in partial stages of gelatinization and perhaps some wholly unaffected. The amount of starch remaining ungelatinized is computed in terms of grains and is estimated by finding the number of grains that are unaffected and the proportions of starch ungelatinized in the partially gelatinized grains. Thus, in the latter case, if there remains an average of one-quarter of the starch unaffected (in some grains it may be one-tenth, in others one-fifth, etc.), it will take four grains to represent the amount of starch in an average grain of the specimen, the number thus determined being added to the number of grains that are unaffected and the sum deducted from the original number under observation, computing thus the percentage of the total starch gelatinized.

When gelatinization occurs very rapidly or very slowly the foregoing method must be modified to suit conditions. Frequently complete or almost complete gelatinization occurs within 15 seconds after the application of the reagent. Obviously time is not permitted for a count of the number of grains in the field before determining the number of grains wholly and partially ungelatinized. By extreme alertness it is possible within 15 seconds after the addition of the reagent to have the slide on the stage of the microscope, select a field, make a count of the ungelatinized grains, and estimate the parts of grains that remain ungelatinized. The number of grains in the field cannot be satisfactorily counted after gelatinization because of the swollen and distorted condition and overlapping of the grains. Hence, in these very rapid reactions the average number of grains in a field is determined beforehand and a corresponding field is selected. It follows from this that the percentage of starch gelatinized under such conditions is very grossly estimated, that no importance is to be attached to the figures beyond the time-limit of complete gelatinization, and that the figures have no value for comparison in cases of starches which likewise are very quickly gelatinized, unless by averages obtained from frequently repeated experiments.

When gelatinization occurs very slowly it often is easier, after having made the count in the field, to determine the number of grains gelatinized and partially gelatinized, as for instance when only 1 per cent of the total starch is gelatinized at the end of 5 minutes or 5 or 10 per cent at the end of an hour.

CONSTANCY OF RESULTS RECORDED BY THE FOREGOING METHOD

It goes without saying that such experiments should be carried out as far as possible under fixed conditions, especially as regards the quantity of starch in

relation to the quantity of reagent. The variations in the quantity of starch, in so far as constant results are concerned, are absolutely negligible, as has been found not only in the records of repeated experiments, but also in the records of varieties of a species when the records should be expected to be very close because of the starches being nearly identical. The quantity of reagent used is invariably two drops, each reagent being kept in a 50 cc. bottle having a glass-stoppered finger pipette dropper with a rubber tip. Under practically identical laboratory conditions as regards quantity of starch, quantity of reagent, temperature, and humidity the results recorded by repeated experiments are either identical or vary within limits that are so narrow as to be absolutely without importance. Even marked variations in temperature and humidity have not been found to be important, except in rare instances.

Obviously, some variations, even though trifling, are to be expected, so that in order to obtain *constants* a given experiment should be repeated a sufficient number of times and an average taken of the records, as in the determination of melting-points. Experience has shown, however, that in so far as the requirements of this particular problem are concerned the results of a single experiment carefully carried out are dependable within narrow and wholly unimportant limits of error. The chief sources of error to be guarded against are leakage through the vaseline seal; the presence of contaminating substances in the starch; certain peculiarities occasionally observed in the behavior of starches towards certain reagents; and errors in estimation when the reactions are very rapid. Leakage through the vaseline seal is sedulously to be avoided, and if a leak occurs the slide and records must be discarded.

The presence of oxalate crystals in the starch is by no means uncommon, but no clear evidence has been found to lead to the belief that, unless in exceptionally large quantity, they in any way influence the course or time of gelatinization by the reagents used. Occasionally foreign matter in the form of undetermined débris is present which cannot be gotten rid of by repeated washing, as in *Tritonia Pottsii*. Such matter may affect the polarization, iodine, and aniline reactions to a detectable degree, but no effect has been noted in the other reactions. With the exception of this starch all have been free from such contamination. Finally, when the reactions are very rapid, while satisfactory records may not be obtained for comparison with those of other starches which gelatinize with similar rapidity, changes in the concentrations of the reagents can be made so as to lengthen the time of the reactions and thus permit of satisfactory differentiation.

COMPARATIVE VALUATIONS OF THE REACTION-INTENSITIES

Throughout all of the reactions definite standards of comparison were adopted, varying somewhat with the different agents, yet all forming a definite coordinate system based upon common abscissae. Thus, the reaction-values in the polarization, iodine, gentian violet, and safranin reactions are based upon a "light and color reaction" scale up to 105, from 0 to less than 20 being grouped as very low or very light, 20 to less than 40 as low to light, 40 to less than 60 as moderate, 60 to less than 80 as high or deep, and 80 to 105 as very high or very deep; the terms very low, low, moderate, high, and very high are applied to the polarization reactions; and very light, light, moderate, deep, and very deep to the iodine and aniline reactions, the sets of terms being synonymous in so far as comparative values are concerned. The reactive-values of the temperature of gelatinization experiments range from 42° to 95° C. ("temperature of gelatinization" scale), 82.5° corresponding to 20, 72.5° to 40, 62.5° to 60, 52.5° to 80, and 42.5° to 100, of the foregoing scale. The reaction-values of the reactions with the various chemical reagents are, as previously stated, in terms of complete and partial gelatinization—of complete gelatinization within a period of 60 minutes, and of percentage of total starch gelatinized in 60 minutes, the scale consisting of two

parts in accordance with this division. These reactive-values based upon the light and color scale of 105, are as follows: 50 per cent of the total starch gelatinized in 60 minutes corresponding to 20, and 90 per cent to 40; complete gelatinization in 45 minutes to 60, in 25 minutes to 80, and in 5 minutes to 100.

USE OF THE REICHERT ANALYSIS IN THE DIFFERENTIAL ANALYSIS OF STARCH

For example, a starch sample of unknown origin has been analyzed according to the above-described Reichert methods and found to have the following properties: polarization light to fair, iodine reaction fair to dark, gentian violet reaction zero to very light, safranin reaction zero to very light, temperature of gelatinization 65°, chloral hydrate-iodine reaction 5-10 minutes, chromic acid reaction 0-1 minute, pyrogallic acid reaction 0-5 minutes, ferric chloride reaction 5-10 minutes, and Purdy's reaction 55-60 minutes. If the starch is one of the 350 starches analyzed by Reichert the plant from which it has been derived may be determined by making use of Reichert's tables which have here been rearranged so as to be more readily available for analysis.

On comparison of the light to fair polarization property of the unknown sample of starch with Table A it is found that it may be one of a group of 39 starches. However, the unknown starch has a fair to dark coloration with iodine. If the 39 starches just mentioned be compared with the starches in Table B which have a fair to dark iodine coloration it is found that 18 of the 39 fall in the fair to dark group. The unknown starch has a gentian violet reaction of zero to very light. Of the 18 starches just mentioned there are only four which have an equivalent gentian violet reaction. The unknown starch has a zero to very light reaction with safranin. Of the four starches just mentioned all four have a similar safranin coloration.

To continue the comparison it is found that these four starches all have different temperatures of gelatinization; namely, 85.5°, 65°, 61°, and 58°. The unknown sample has a chloral hydrate-iodine reaction of 5-10 minutes. It is found by comparison in Table F that only one of the four starches, namely, that of *Zea Mays saccharata* (Black Mexican), has a 5-10 minute chloral hydrate-iodine reaction. Therefore the conclusion is that the unknown starch had as its origin *Zea Mays saccharata* (Black Mexican), that is, sweet corn of the Black Mexican variety.

THE DEGREES OF POLARIZATION OF VARIOUS STARCHES

TABLE A

0-VL, zero to very low
- Richardia africana
- Hedychium Gardnerianum
- Marica gracilis

VL-L, very low to low
- Triticum sativum var. vulgare
- Triticum sativum var. dicoccum
- Pisum sativum var. (Eugenie, green)
- Pisum sativum var. (Thos. Laxton)
- Tigridia Pavonia var. grandiflora alba
- Tigridia Pavonia var. conchiflora
- Musa Cavendishii
- Zingiber officinale var. Jamaica, No. 1
- Zingiber officinale var. Jamaica, No. 2
- Zingiber officinale var. Cochin
- Hedychium coronarium
- Anemone apennina
- Anemone blanda
- Aconitum Napellus
- Actaea alba
- Actaea spicata var. rubra
- Cimicifuga racemosa
- Ranunculus bulbosus

L-F, low to fair
- Zea Mays var. saccharata (B. Mex.)
- Panicum Crus-galli var.
- Oryza sativa var.
- Secale cereale var. (Mammoth Winter)
- Hordeum sativum var. (Champion)
- Avena sativa var. (Clydesdale)
- Arrhenatherum elatius var.
- Dolichos Lablab
- Lathyrus sylvestris
- Pisum sativum var. (Eugenie, yellow)
- Pisum sativum var. (Mam. G. Seeded)
- Quercus rubra
- Arum palaestinum
- Richardia Elliotiana
- Richardia albo-maculata
- Dieffenbachia seguine var. nobilis (cortex)
- Dieffenbachia seguine var. irrorata (cortex)
- Erythronium Dens-canis
- Erythronium grandiflorum
- Lachenalia pendula
- Lachenalia tricolor var. luteola
- Convallaria majalis
- Trillium grandiflorum
- Trillium ovatum
- Trillium sessile var. californicum
- Iris florentina
- Tritonia crocata
- Cypella Herberti
- Ixia speciosa
- Ixia viridiflora
- Babiana var. (violacea)
- Babiana var. (Athraction)
- Musa Cavendishii (green fruit)
- Curcuma longa
- Calathea Lietzei
- Calathea Wiotiana
- Anemone fulgens
- Anemone japonica
- Cochlearia Armoracia

F-H, fair to high
- Zea Mays var. everta (Golden Queen)
- Zea Mays var. everta (White Rice)
- Zea Mays var. indurata (N. Dakota)
- Zea Mays var. indurata (C.'s Early)
- Zea Mays var. indentata (E'y L'g)
- Zea Mays var. indentata (H. King)
- Zea Mays var. saccharata (S.'s E'n)
- Zea Mays var. saccharata (G. B'm)
- Andropogon Sorghum var. (W. K. Corn)
- Andropogon Sorghum var. (Shallu)
- Secale cereale var. (Spring)
- Vicia sativa
- Vicia villosa
- Vicia Faba
- Phaseolus vulgaris var. (Red K. Bean)
- Phaseolus lunatus var. (H.'s B. Lima)
- Lathyrus odoratus var. Shahzada
- Lathyrus latifolius var. albus
- Lathyrus magellanicus var. albus
- Pisum sativum var. (Elec. E. Early)
- Pisum sativum var. (L. W. Marrowfat)
- Wistaria chinensis
- Arachis hypogaea
- Polygonum Fagopyrum var. (American)
- Polygonum Fagopyrum var. (Japanese)
- Quercus alba
- Quercus Muhlenbergii
- Quercus Prinus
- Quercus texana
- Castanea americana
- Castanea sativa var. numbo
- Castanea sativa var.

Castanea pumila
Aesculus Hippocastanum
Arum cornutum
Arum italicum
Arisaema triphyllum
Dracunculus vulgaris
Dieffenbachia seguine var. nobilis (pith)
Dieffenbachia seguine var. maculata (cortex)
Dieffenbachia seguine var. irrorata (pith)
Dieffenbachia illustris (cortex)
Lilium candidum
Lilium longiflorum var. giganteum
Lilium longiflorum var. eximium
Lilium Parryi
Lilium rubellum
Lilium philadelphicum
Lilium tigrinum var. splendens
Lilium auratum
Lilium speciosum var. album
Lilium martagon
Lilium superbum
Lilium tenuifolium
Lilium pardalinum
Lilium puberulum
Fritillaria meleagris
Fritillaria pyrenaica
Fritillaria pudica
Fritillaria aurea
Fritillaria armena
Fritillaria imperialis var. Aurora
Fritillaria liliacea
Calochortus albus
Calochortus nitidus
Calochortus splendens
Tulipa Hageri
Tulipa sylvestris
Tulipa Greigi
Tulipa Billietiana
Tulipa Didieri
Tulipa Didieri var. Mauriana
Tulipa Didieri var. Fransoniana
Tulipa Clusiana
Tulipa Clusiana var. persica
Tulipa oculus-solis
Tulipa praecox
Tulipa australis
Scilla sibirica
Scilla peruviana
Scilla bifolia
Chionodoxa Lucillae
Chionodoxa Tmolusi
Chionodoxa sardensis
Puschkinia scilloides
Puschkinia scilloides var. libanotica
Ornithogalum nutans
Ornithogalum umbellatum
Ornithogalum narbonense (pyramidale)
Erythronium Dens-canis var. grand.
Erythronium americanum
Erythronium citrinum
Erythronium californicum
Hyacinthus orientalis var. alba superba
Hyacinthus orientalis var. albulus (Italian)
Muscari botryoides
Muscari paradoxum
Muscari micranthum
Muscari commutatum
Muscari compactum
Muscari comosum
Brodiaea peduncularis
Brodiaea ixioides var. splendens
Brodiaea lactea
Brodiaea laxa
Brodiaea coccinea
Brodiaea grandiflora
Brodiaea californica
Brodiaea Purdyi
Brodiaea stellaris
Brodiaea congesta
Triteleia uniflora
Colchicum Parkinsoni
Amaryllis belladonna major
Hippeastrum vittatum
Hippeastrum equestre
Hippeastrum aulicum var. robustum
Vallota purpurea
Zephyranthes candida
Zephyranthes rosea
Sprekelia formosissima
Haemanthus Katherinae
Hymenocallis undulata
Leucojum vernum
Leucojum aestivum
Galanthus nivalis
Galanthus Elwesii
Alstroemeria brasiliensis
Sternbergia lutea
Narcissus Horsfieldii
Narcissus maximus
Narcissus Bulbocodium
Narcissus Bulbocodium var. conspicuus
Narcissus Bulbocodium var. monophyllus
Narcissus incomparabilis
Narcissus odorus
Narcissus poeticus
Narcissus biflorus
Narcissus Jonquilla
Narcissus Jonquilla var. Campernelli rug.
Narcissus tazetta var. orientalis
Tacca pinnatifida
Iris pallida var. speciosa
Iris pumila var. cyanea
Iris Bismarckiana
Iris iberica
Homeria collina

Moraea tristis
Gladiolus byzantinus
Gladiolus primulinus
Gladiolus cardinalis (Blushing Bride)
Gladiolus floribundus
Watsonia humilis
Watsonia iridifolia var. O'Brieni
Watsonia Meriana
Tritonia crocata var. lilacina
Tritonia crocata var. rosea
Tritonia securigera
Tritonia Pottsii
Tritonia crocosmaeflora
Freesia refracta var. alba
Freesia refracta var. Leichtlinii
Antholyza crocosmoides
Antholyza paniculata
Crocus Susianus (Cloth of Gold)
Crocus versicolor (Cloth of Silver)
Crocus var. (Baron von Brunow)
Romulea rosea var. speciosa
Gelasine azurea
Sparaxis grandiflora var. alba
Sparaxis var. (Albertine)
Ixia var. (Emma)
Curcuma petiolata
Canna var. (Königin Charlotte)
Canna var. (President Carnot)
Canna var. (L. F. Baily)
Canna var. (Jean Tissot)
Maranta arundinacea
Maranta arundinacea var. No. 1
Maranta arundinacea var. No. 2
Maranta Massangeana
Maranta leuconeura
Maranta musaica
Calathea vittata
Calathea Wiotiana
Stromanthe sanguinea
Nymphaea alba
Nymphaea marliacea var. albida
Nymphaea marliacea var. carnea
Nymphaea Gladstoniana
Nymphaea odorata
Nymphaea odorata var. rosea
Nelumbo nucifera
Nelumbo lutea
Eranthus hyemalis
Ranunculus Ficaria
Cochlearia Armoracia
Manihot utilissima
Cyclamen repandum
Cyclamen coum
Batatas edulis
Gesneria tubiflora
Gloxinia var.
Trianosperma ficifolia
Cycas revoluta
Cycas circinalis
Dioon edule

H-VH, high to very high
Andropogon Sorghum var. (Y. B. Sorgh.)
Vicia fulgens
Vicia Gerardi
Vicia villosa
Vicia Faba
Mucuna pruriens
Lens esculenta
Dieffenbachia seguine var. maculata (pith)
Dieffenbachia illustris (pith)
Lilium Henryi
Fritillaria recurva
Calochortus Maweanus var. major
Calochortus Benthami
Calochortus lilacinus
Calochortus Leichtlinii
Calochortus luteus var. oculatus
Ornithogalum thyrsoides var. aureum
Galtonia candicans
Crinum fimbriatulum
Crinum americanum
Alstroemeria brasiliensis
Alstroemeria aurantiaca (aurea)
Narcissus Jonquilla var. rugulosus
Iris xiphium var. Grand Tresorier
Iris xiphium var. Wilhelmine
Iris xiphium var. lusitanica
Iris tingitana
Iris reticulata
Iris Histrio
Iris alata
Iris caucasica
Canna Warscewiczii
Canna Roscoeana
Canna edulis
Canna var. (Mrs. Kate Grey)
Canna var. (L. D. Eisele)
Jatropha Curcas
Solanum tuberosum
Zamia integrifolia

THE IODINE REACTIONS OF VARIOUS STARCHES

TABLE B

0-VL, zero to very light coloration
None

VL-L, very light to light coloration
Panicum Crus-galli var.
Oryza sativa var.
Hordeum sativum var. (Champion)
Avena sativa var. (Clydesdale)
Arrhenatherum elatius var.
Pisum sativum var. (Thos. Laxton)

Polygonum Fagopyrum var. (American)
Polygonum Fagopyrum var. (Japanese)
Watsonia humilis
Watsonia Meriana
Tritonia Pottsii
Antholyza crocosmoides
Antholyza paniculata
Romulea rosea var. speciosa
Babiana var. (violacea)
Babiana var. (Athraction)
Curcuma longa
Stromanthe sanguinea
Nymphaea Gladstoniana
Manihot utilissima
Zamia integrifolia

L-F, light to fair coloration

Triticum sativum var. vulgare
Dolichos Lablab
Lathyrus odoratus var. Shahzada
Lathyrus magellanicus var. albus
Pisum sativum var. (Eugenie, yellow)
Pisum sativum var. (Eugenie, green)
Pisum sativum var. (Elec. E. Early)
Quercus alba
Quercus Muhlenbergii
Quercus Prinus
Quercus rubra
Quercus texana
Fritillaria armena
Colchicum Parkinsoni
Vallota purpurea
Watsonia iridifolia var. O'Brieni
Tritonia crocata
Tritonia securigera
Tritonia crocosmaeflora
Hedychium coronarium
Hedychium Gardnerianum
Curcuma petiolata
Calathea vittata
Calathea Vandenheckei
Nymphaea alba
Nymphaea marliacea var. albida
Nymphaea marliacea var. carnea
Nymphaea odorata
Nymphaea odorata var. rosea

F-D, fair to dark coloration

Zea Mays var. everta (Golden Queen)
Zea Mays var. everta (White Rice)
Zea Mays var. indurata (N. Dakota)
Zea Mays var. indurata (C.'s Early)
Zea Mays var. indentata (E'y L'g)
Zea Mays var. indentata (H. King)
Zea Mays var. saccharata (S.'s E'n)
Zea Mays var. saccharata (B. Mex.)
Zea Mays var. saccharata (G. B'm)
Andropogon Sorghum var. (W. K. Corn)
Andropogon Sorghum var. (Y. B. Sorgh.)
Andropogon Sorghum var. (Shallu)
Triticum sativum var. dicoccum
Secale cereale var. (Mammoth Winter)
Secale cereale var. (Spring)
Vicia sativa
Vicia villosa
Vicia Faba
Vicia fulgens
Vicia Gerardi
Phaseolus vulgaris var. (Red K. Bean)
Phaseolus limatus var. (H.'s B. Lima)
Mucuna pruriens
Lens esculenta
Lathyrus sylvestris
Lathyrus latifolius var. albus
Pisum sativum var. (Mam. G. Seeded)
Pisum sativum var. (L. W. Marrowfat)
Wistaria chinensis
Arachis hypogaea
Castanea americana
Castanea sativa var. numbo
Castanea pumila
Castanea sativa var.
Aesculus Hippocastanum
Arum palaestinum
Arum italicum
Arisaema triphyllum
Richardia Elliotiana
Richardia africana
Dieffenbachia seg. var. nob. (pith)
Dieffenbachia seg. var. nob. (cort.)
Dieffenbachia seg. var. irror. (pith)
Dieffenbachia seg. var. irror. (cort.)
Dieffenbachia illustris (cortex)
Lilium candidum
Lilium longiflorum var. giganteum
Lilium longiflorum var. eximium
Lilium Parryi
Lilium rubellum
Lilium philadelphicum
Lilium Henryi
Lilium auratum
Lilium martagon
Lilium tenuifolium
Lilium pardalinum
Lilium puberulum
Fritillaria meleagris
Fritillaria pyrenaica
Fritillaria pudica
Fritillaria aurea
Fritillaria imperialis var. Aurora
Fritillaria liliacea
Fritillaria recurva
Tulipa Hageri
Tulipa Billietiana
Tulipa Didieri
Tulipa Didieri var. mauriana
Tulipa Didieri var. Fransoniana

Colchicum Parkinsoni
Haemanthus Katherinae
Leucojum vernum
Leucojum aestivum
Gladiolus byzantinus
Gladiolus primulinus
Gladiolus floribundus
Tritonia crocata
Tritonia crocata var. lilacina
Tritonia crocata var. rosea
Tritonia securigera
Romulea rosea var. speciosa
Maranta leuconeura
Calathea Wiotiana
Cimicifuga racemosa
Adonis amurensis
Manihot utilissima

VL-L, very light to light coloration

Zea Mays var. everta (Golden Queen)
Zea Mays var. everta (White Rice)
Zea Mays var. indurata (N. Dakota)
Zea Mays var. indurata (C.'s Early)
Zea Mays var. indentata (E'y L'g)
Zea Mays var. indentata (H. King)
Andropogon Sorghum var. (W. K. Corn)
Andropogon Sorghum var. (Y. B. Sorgh.)
Andropogon Sorghum var. (Shallu)
Panicum Crus-galli var.
Oryza sativa var.
Secale cereale var. (Mammoth Winter)
Secale cereale var. (Spring)
Avena sativa var. (Clydesdale)
Arrhenatherum elatius var.
Vicia Faba
Phaseolus vulgaris var. (Red K. Bean)
Phaseolus lunatus var. (H.'s B. Lima)
Dolichos Lablab
Mucuna Pruriens
Lens esculenta
Lathyrus odoratus var. Shahzada
Lathyrus sylvestris
Lathyrus latifolius var. albus
Pisum sativum var. (Elec. E. Early)
Pisum sativum var. (Mam. G. Seeded)
Pisum sativum var. (L. W. Marrowfat)
Wistaria chinensis
Arachis hypogaea
Aesculus Hippocastanum
Arum palaestinum
Arum italicum
Richardia Elliotiana
Richardia africana
Richardia albo-maculata
Lilium candidum
Lilium longiflorum var. giganteum
Lilium longiflorum var. eximium
Lilium auratum
Lilium speciosum var. album
Lilium martagon
Lilium superbum
Lilium pardalinum
Lilium puberulum
Fritillaria aurea
Fritillaria armena
Puschkinia scilloides
Puschkinia scil. var. libanotica
Erythronium Dens-canis
Hyacinthus orientalis var. albus superbus
Hyacinthus orientalis var. albulus (Italian)
Galtonia candicans
Brodiaea peduncularis
Brodiaea ixioides var. splendens
Brodiaea stellaris
Triteleia uniflora
Crinum fimbriatulum
Zephyranthes candida
Hymenocallis undulata
Hymenocallis calathina
Narcissus maximus
Narcissus Bulbocodium var. conspicuus
Narcissus incomparabilis
Narcissus Jonquilla
Tacca pinnatifida
Iris florentina
Iris pallida speciosa
Iris pumila var. cyanea
Iris Bismarckiana
Iris iberica
Moraea tristis
Tigridia Pavonia var. grand. alba
Tritonia crocosmaeflora
Crocus Susianus (Cloth of Gold)
Crocus versicolor (Cloth of Silver)
Marica gracilis
Gelasine azurea
Gelasine azurea
Sparaxis grandiflora var. alba
Ixia speciosa
Ixia var. (Emma)
Maranta Massangeana
Maranta musaica
Stromanthe sanguinea
Nymphaea alba
Nymphaea marliacea var. albida
Nymphaea Gladstoniana
Nymphaea odorata var. rosea
Aconitum Napellus
Actaea alba
Actaea spicata var. rubra
Ranunculus bulbosus
Zamia integrifolia

L-F, light to fair coloration

Lilium Parryi

Lilium philadelphicum
Lilium tigrinum var. splendens
Lilium Henryi
Lilium tenuifolium
Fritillaria meleagris
Fritillaria pudica
Fritillaria liliacea
Calochortus Maweanus var. major
Calochortus nitidus
Calochortus splendens
Tulipa Hageri
Tulipa sylvestris
Tulipa Didieri var. Fransoniana
Scilla sibirica
Scilla bifolia
Chionodoxa Lucillae
Chionodoxa Tmolusi
Chionodoxa sardensis
Puschkinia scilloides var. libanotica
Erythronium Dens-canis var. grand.
Erythronium americanum
Erythronium grandiflorum
Erythronium citrinum
Erythronium californicum
Hyacinthus orientalis var. albulus (White)
Muscari commutatum
Brodiaea candida
Brodiaea lactea
Brodiaea laxa
Brodiaea grandiflora
Brodiaea congesta
Lachenalia pendula
Lachenalia tricolor var. luteola
Amaryllis belladonna major
Vallota purpurea
Crinum americanum
Zephyranthes rosea
Sprekelia formosissima
Sternbergia lutea
Narcissus Horsfieldii
Narcissus Bulbocodium
Narcissus Bulbocodium var. monophyllus
Narcissus odorus
Narcissus poeticus
Narcissus biflorus
Narcissus Jonquilla var. rugulosus
Narcissus Jonquilla var. Campernelli rug.
Narcissus tazetta var. orientalis
Iris xiphium var. Grand Tresorier
Iris xiphium var. Wilhelmine
Iris xiphium var. lusitanica
Iris tingitana
Iris reticulata
Iris Histrio
Iris alata
Iris caucasica
Homeria collina
Tigridia Pavonia var. conchiflora
Gladiolus cardinalis (Blush'g Bride)
Watsonia Meriana
Tritonia Pottsii
Freesia refracta var. alba
Antholyza crocosmoides
Antholyza paniculata
Crocus var. (Baron von Brunow)
Cypella Herberti
Sparaxis var. (Albertine)
Ixia viridiflora
Babiana var. (violacea)
Babiana var. (Athraction)
Curcuma longa
Maranta arundinacea
Calathea vittata
Calathea Vandenheckei
Nymphaea marliacea var. carnea
Nymphaea odorata
Nelumbo nucifera
Nelumbo lutea
Anemone apennina
Anemone fulgens
Anemone blanda
Cochlearia Armoracia
Batatas edulis
Gloxinia var.
Dioon edule

F-D, fair to dark coloration

Dracunculus vulgaris
Dieffenbachia seg. var. nob. (pith)
Dieffenbachia seg. var. nob. (cort.)
Dieffenbachia seg. var. irror. (cort.)
Dieffenbachia illustris (pith)
Dieffenbachia illustris (cort.)
Fritillaria pyrenaica
Fritillaria recurva
Calochortus albus
Calochortus Benthami
Calochortus lilacinus
Calochortus Howellii
Calochortus Leichtlinii
Calochortus luteus var. oculatus
Tulipa Greigi
Tulipa Billietiana
Tulipa Didieri
Tulipa Didieri var. mauriana
Tulipa Clusiana
Tulipa Clusiana var. persica
Tulipa oculus-solis
Tulipa praecox
Tulipa australis
Scilla peruviana
Ornithogalum nutans
Ornithogalum umbellatum
Ornithogalum narbonense (pyramidale)
Ornithogalum thyrsoides var. aureum
Muscari botryoides
Muscari racemosum
Brodiaea coccinea
Brodiaea californica
Brodiaea Purdyi

Brodiaea capitata
Hippeastrum vittatum
Hippeastrum equestre
Hippeastrum aulicum var. robustum
Galanthus nivalis
Galanthus Elwesii
Alstroemeria ligtu
Watsonia humilis
Watsonia iridifolia var. O'Brieni
Freesia refracta var. Leichtlinii
Musa Cavendishii
Musa Cavendishii (green fruit)
Musa ensete
Zingiber officinale
Zingiber officinale var. Jamaica No. 1
Zingiber officinale var. Jamaica No. 2
Zingiber officinale var. Cochin
Hedychium coronarium
Hedychium Gardnerianum
Curcuma petiolata
Canna Warscewiczii
Canna Roscoeana
Canna musaefolia
Canna edulis
Canna var. (Königin Charlotte)
Canna var. (President Carnot)
Canna var. (L. E. Baily)
Canna var. (Mrs. Kate Grey)
Maranta arundinacea var. No. 1
Maranta arundinacea var. No. 2
Calathea Lietzei
Anemone japonica
Eranthis hyemalis
Ranunculus Ficaria
Jatropha Curcas
Cyclamen repandum
Cyclamen coum
Gesneria tubiflora
Trianosperma ficifolia
Cycas revoluta
Cycas circinalis

D-VD, dark to very dark coloration
Dieffenbachia seg. var. mac. (pith)
Dieffenbachia seg. var. mac. (cort.)
Dieffenbachia seg. var. irror. (pith)
Muscari paradoxum
Muscari micranthum
Muscari conicum
Muscari compactum
Muscari comosum
Alstroemeria brasiliensis
Alstroemeria aurantiaca (aurea)
Musa sapientum
Canna var. (Jean Tissot)
Canna var. (J. D. Eisele)
Solanum tuberosum

THE SAFRANIN REACTIONS OF VARIOUS STARCHES

TABLE D

0-VL, zero to very light coloration
Zea Mays var. everta (Golden Queen)
Zea Mays var. everta (White Rice)
Zea Mays var. saccharata (S.'s E'n)
Zea Mays var. saccharata (B. Mex.)
Zea Mays var. saccharata (G. B'm)
Hordeum sativum var. (Champion)
Pisum sativum var. (Eugenie, yellow)
Pisum sativum var. (Eugenie, green)
Pisum sativum var. (Thos. Laxton)
Quercus alba
Quercus Muhlenbergi
Quercus Prinus
Castanea americana
Castanea sativa var. numbo
Castanea sativa var.
Castanea pumila
Arum italicum
Richardia Elliotiana
Richardia africana
Richardia albo-maculata
Lilium longiflorum var. eximium
Lilium rubellum
Lilium martagon
Fritillaria armena
Fritillaria imperialis var. Aurora
Convallaria majalis
Trillium grandiflorum
Trillium ovatum
Trillium sessile var. californicum
Tritoma securigera
Romulea rosea var. speciosa
Gelasine azurea
Calathea Wiotiana
Actaea spicata var. rubra
Cimicifuga racemosa
Adonis amurensis
Cycas revoluta
Cycas circinalis

VL-L, very light to light coloration
Zea Mays var. indurata (N. Dakota)
Zea Mays var. indurata (C.'s Early)
Zea Mays var. indentata (E'y L'g)
Zea Mays var. indentata (H. King)
Andropogon Sorghum var. (W. K. Corn)
Andropogon Sorghum var. (Y. B. Sorgh.)
Andropogon Sorghum var. (Shallu)
Panicum Crus-galli var.
Oryza sativa var.
Triticum sativum var. vulgare
Triticum sativum var. dicoccum
Secale cereale var. (Mammoth Winter)

Secale cereale var. (Spring)
Avena sativa var. (Clydesdale)
Arrhenatherum elatius var.
Vicia sativa
Vicia villosa
Vicia fulgens
Vicia Gerardi
Phaseolus vulgaris var. (Red K. Bean)
Phaseolus lunatus var. (H.'s B. Lima)
Dolichos Lablab
Mucuna pruriens
Lens esculenta
Lathyrus odoratus var. Shahzada
Lathyrus sylvestris
Lathyrus latifolius var. albus
Pisum sativum var. (Elec. E. Early)
Pisum sativum var. (Mam. G. Seeded)
Pisum sativum var. (L. W. Marrowfat)
Wistaria chinensis
Arachis hypogaea
Polygonum Fagopyrum var. (American)
Polygonum Fagopyrum var. (Japanese)
Quercus rubra
Quercus texana
Aesculus Hippocastanum
Arum palaestinum
Lilium candidum
Lilium longiflorum var. giganteum
Lilium Parryi
Lilium philadelphicum
Lilium tigrinum var. splendens
Lilium Henryi
Lilium auratum
Lilium speciosum var. album
Lilium superbum
Lilium tenuifolium
Lilium pardalinum
Lilium puberulum
Fritillaria aurea
Tulipa Hageri
Tulipa sylvestris
Puschkinia scilloides
Erythronium Dens-canis
Erythronium Dens-canis var. grand.
Erythronium americanum
Erythronium californicum
Hyacinthus orientalis var. albus superb.
Hyacinthus orientalis var. albulus (Italian)
Colchicum Parkinsoni
Zephyranthes candida
Haemanthus Katherinae
Hymenocallis undulata
Hymenocallis calathina
Leucojum vernum
Leucojum aestivum
Narcissus Bulbocodium
Narcissus Bulbocodium var. conspicuus
Narcissus Bulbocodium var. monophyllus
Narcissus incomparabilis
Narcissus poeticus
Narcissus biflorus
Narcissus Jonquilla
Narcissus Jonquilla var. Campernelli rug.
Tacca pinnatifida
Iris florentina
Iris pallida speciosa
Iris pumila var. cyanea
Iris Bismarckiana
Moraea tristis
Tigridia Pavonia var. grand. alba
Gladiolus primulinus
Watsonia Meriana
Freesia refracta var. alba
Marica gracilis
Sparaxis grandiflora alba
Zingiber officinale
Zingiber officinale var. Jamaica No. 1
Zingiber officinale var. Jamaica No. 2
Zingiber officinale var. Cochin
Maranta leuconeura
Stromanthe sanguinea
Nymphaea Gladstoniana
Nymphaea odorata var. rosea
Anemone apennina
Anemone fulgens
Anemone blanda
Aconitum Napellus
Actaea alba
Ranunculus bulbosus

L-F, light to fair coloration
Vicia Faba
Lathyrus magellanicus var. albus
Arisaema triphyllum
Fritillaria meleagris
Fritillaria pyrenaica
Fritillaria pudica
Fritillaria liliacea
Fritillaria recurva
Tulipa Greigi
Tulipa Billietiana
Tulipa Didieri
Tulipa Didieri var. mauriana
Tulipa Didieri var. Fransoniana
Tulipa Clusiana
Tulipa Clusiana var. persica
Tulipa oculus-solis
Tulipa praecox
Tulipa australis
Puschkinia scilloides var. libanotica
Erythronium grandiflorum
Erythronium citrinum
Hyacinthus orientalis var. albulus (White)

Galtonia candicans
Muscari commutatum
Brodiaea peduncularis
Brodiaea ixioides var. splendens
Brodiaea candida
Brodiaea lactea
Brodiaea laxa
Brodiaea californica
Brodiaea stellaris
Brodiaea capitata
Brodiaea congesta
Triteleia uniflora
Lachenalia pendula
Crinum fimbriatulum
Zephyranthes rosea
Narcissus Horsfieldii
Narcissus maximus
Narcissus odorus
Narcissus Jonquilla var. rugulosus
Narcissus tazetta var. orientalis
Iris iberica
Iris xiphium var. Grand Tresorier
Iris xiphium var. Wilhelmine
Iris xiphium var. lusitanica
Iris tingitana
Iris reticulata
Iris Histrio
Iris alata
Iris caucasica
Homeria collina
Tigridia Pavonia var. conchiflora
Gladiolus byzantinus
Gladiolus cardinalis (Blushing Bride)
Gladiolus floribundus
Tritonia crocata
Tritonia crocata var. lilacea
Tritonia crocata var. rosea
Tritonia Pottsii
Tritonia crocosmaeflora
Freesia refracta var. Leichtlinii
Antholyza crocosmoides
Antholyza paniculata
Crocus Susianus (Cloth of Gold)
Crocus versicolor (Cloth of Silver)
Crocus var. (Baron von Brunow)
Cypella Herberti
Sparaxis var. (Albertine)
Ixia speciosa
Ixia var. (Emma)
Babiana var. (violacea)
Curcuma longa
Maranta Massangeana
Maranta musaica
Calathea vittata
Calathea Vandenheckei
Nymphaea alba
Nymphaea marliacea var. albida
Nelumbo nucifera
Nelumbo lutea
Anemone japonica
Cochlearia Armoracia
Cyclamen repandum
Cyclamen coum
Gloxinia var.
Zamia integrifolia

F-D, fair to dark coloration
Arum cornutum
Dracunculus vulgaris
Dieffenbachia seg. var. nob. (pith)
Dieffenbachia seg. var. nob. (cort.)
Dieffenbachia seg. var. mac. (cort.)
Dieffenbachia seg. var. irror. (pith)
Dieffenbachia seg. var. irror. (cort.)
Dieffenbachia illustris (pith)
Dieffenbachia illustris (cortex)
Calochortus albus
Calochortus Maweanus var. major
Calochortus Benthami
Calochortus lilacinus
Calochortus nitidus
Calochortus Howellii
Calochortus Leichtlinii
Calochortus luteus var. oculatus
Calochortus splendens
Scilla sibirica
Scilla peruviana
Scilla bifolia
Chionodoxa Lucillae
Chionodoxa Tmolusi
Chionodoxa sardensis
Ornithogalum narbonense (pyramidale)
Muscari botryoides
Muscari paradoxum
Muscari micranthum
Muscari conicum
Muscari racemosum
Muscari compactum
Muscari comosum
Brodiaea coccinea
Brodiaea grandiflora
Brodiaea Purdyi
Lachenalia tricolor var. luteola
Amaryllis belladonna major
Hippeastrum vittatum
Hippeastrum equestre
Hippeastrum aulicum var. robustum
Vallota purpurea
Crinum americanum
Sprekelia formosissima
Galanthus nivalis
Galanthus Elwesii
Alstroemeria ligtu
Sternbergia lutea
Watsonia humilis
Watsonia iridifolia var. O'Brieni
Ixia viridiflora
Babiana var. (Athraction)
Musa Cavendishii
Musa Cavendishii (green fruit)
Musa sapientum
Hedychium coronarium
Hedychium Gardnerianum

Curcuma petiolata
Canna Roscoeana
Canna edulis
Canna var. (Königin Charlotte)
Canna var. (President Carnot)
Canna var. (L. E. Baily)
Canna var. (Mrs. Kate Grey)
Maranta arundinacea
Maranta arundinacea var. No. 1
Maranta arundinacea var. No. 2
Calathea Lietzei
Nymphaea marliacea var. carnea
Nymphaea odorata
Eranthis hyemalis
Ranunculus Ficaria
Jatropha Curcas
Manihot utilissima
Batatas edulis
Gesneria tubiflora
Trianosperma ficifolia
Dioon edule

D-VD, dark to very dark coloration
Dieffenbachia seg. var. mac. (pith)
Ornithogalum nutans
Ornithogalum umbellatum
Ornithogalum thyrsoides var. aureum
Alstroemeria brasiliensis
Alstroemeria aurantiaca (aurea)
Musa ensete
Canna Warscewiczii
Canna musaefolia
Canna var. (Jean Tissot)
Canna var. (J. D. Eisele)
Solanum tuberosum

THE TEMPERATURES OF GELATINIZATION OF VARIOUS STARCHES

TABLE E

	Degrees Centigrade
Fritillaria pudica	49.60
Tulipa Greigi	50.30
Erythronium citrinum	50.45
Calochortus Howellii	50.50
Tulipa Didieri	50.75
Tulipa Didieri var. mauriana	50.95
Tulipa australis	51.15
Lilium Parryi	52.60
Erythronium Dens-canis	52.65
Calochortus albus	53.00
Erythronium grandiflorum	53.00
Erythronium americanum	53.45
Tulipa oculus-solis	53.75
Erythronium Dens-canis var. grandiflorum	54.00
Tulipa Clusiana var. persica	54.75
Alstroemeria aurantiaca (aurea)	54.75
Calochortus nitidus	54.75
Tulipa Didieri var. Fransoniana	54.85
Cypella Herberti	55.00
Trillium sessile var. californicum	55.00
Fritillaria liliacea	55.10
Calochortus splendens	55.10
Tulipa Billietiana	55.25
Ornithogalum narbonense (pyramidale)	55.50
Tulipa praecox	55.80
Lilium Henryi	56.00
Puschkinia scilloides	56.35
Puschkinia scilloides var. libanotica	56.70
Trillium ovatum	56.75

	Degrees Centigrade
Ornithogalum umbellatum	56.75
Tulipa Hageri	56.90
Tulipa Clusiana	57.10
Tulipa sylvestris	57.15
Lilium tenuifolium	57.30
Alstroemeria brasiliensis	57.75
Erythronium californicum	57.90
Trillium grandiflorum	58.00
Lathyrus sylvestris	58.00
Calochortus luteus var. oculatus	58.10
Alstroemeria ligtu	58.50
Galtonia candicans	58.60
Lilium auratum	58.60
Fritillaria recurva	58.70
Calochortus lilacinus	59.00
Lilium martagon	59.10
Castanea americana	59.25
Calochortus Maweanus var. major	59.50
Fritillaria meleagris	59.50
Castanea pumila	59.75
Tigridia Pavonia var. conchiflora	60.00
Castanea sativa var. numbo	60.00
Chionodoxa Lucillae	60.00
Arrhenatherum elatius var.	60.25
Lachenalia pendula	60.65
Quercus alba	60.75
Brodiaea laxa	61.00
Convallaria majalis	61.00
Secale cereale var. (Mammoth Winter)	61.00
Tigridia Pavonia var. grandiflora alba	61.00
Hordeum sativum var. (Champion)	61.00
Castanea sativa var.	61.00
Chionodoxa sardensis	61.10
Colchicum Parkinsoni	61.25
Ornithogalum nutans	61.25
Calochortus Benthami	61.50
Lilium superbum	61.60
Lilium candidum	61.65
Brodiaea ixioides var. splendens	61.75
Brodiaea candida	62.00
Secale cereale var. (spring)	62.00
Lilium tigrinum var. splendens	62.05
Lilium puberulum	62.15
Chionodoxa Tmolusi	62.35
Canna var. (J. D. Eisele)	62.50
Canna var. (Mrs. Kate Grey)	62.50
Lilium longiflorum var. giganteum	62.55
Fritillaria aurea	62.75
Triticum sativum var. dicoccum	62.90

	Degrees Centigrade
Calochortus Leichtlinii	63.00
Quercus rubra	63.00
Musa ensete	63.00
Tacca pinnatifida	63.00
Avena sativa var. (Clydesdale)	63.00
Lathyrus latifolius var. albus	63.00
Fritillaria pyrenaica	63.15
Zea Mays var. everta (White Rice)	63.25
Zea Mays var. everta (Golden Queen)	63.25
Lilium pardalinum	63.30
Polygonum Fagopyrum var. (American)	63.50
Quercus Muhlenbergii	63.75
Lilium philadelphicum	63.90
Lilium rubellum	63.95
Triticum sativum var. vulgare	64.00
Dracunculus vulgaris	64.25
Quercus texana	64.25
Lilium speciosum var. album	64.35
Brodiaea lactea	64.50
Iris caucasica	64.50
Scilla bifolia	64.75
Quercus Prinus	64.75
Polygonum Fagopyrum var. (Japanese)	64.75
Zea Mays var. saccharata (Black Mexican)	65.00
Vicia Faba	65.00
Canna var. (Königin Charlotte)	65.25
Iris reticulata	65.25
Iris xiphium var. Grand Tresorier	65.50
Iris tingitana	65.50
Canna var. (President Carnot)	65.50
Scilla peruviana	65.50
Iris Histrio	65.50
Brodiaea capitata	65.57
Lilium longiflorum var. eximium	65.60
Brodiaea grandiflora	65.90
Scilla sibirica	66.00
Vicia villosa	66.00
Ornithogalum thyrsoides var. aureum	66.00
Iris xiphium var. Wilhelmine	66.50
Galanthus nivalis	66.50
Arachis hypogaea	66.50
Iris alata	66.50
Zea Mays var. indentata (Early Leaming)	66.50
Zea Mays var. saccharata (Golden Bantam)	66.50
Fritillaria armena	66.60
Zea Mays var. indentata (Hickory King)	66.75
Zea Mays var. saccharata (Stowell's Evergreen)	66.85
Andropogon Sorghum	66.90
Hyacinthus orientalis var. albus superbissimus	67.00

	Degrees Centigrade
Iris xiphium var. lusitanica	67.00
Brodiaea Purdyi	67.00
Brodiaea californica	67.30
Musa Cavendishii (green fruit)	67.50
Canna edulis	67.50
Musa Cavendishii	67.75
Andropogon Sorghum var. (White Kaffir Corn)	68.00
Musa sapientum	68.00
Muscari comosum	68.00
Zea Mays var. indurata (North Dakota)	68.00
Brodiaea stellaris	68.10
Fritillaria imperialis var. Aurora	68.40
Lathyrus odoratus var. Shahzada	68.50
Hymenocallis calathina	68.50
Pisum sativum var. (Large White Marrowfat)	68.50
Brodiaea peduncularis	68.50
Zea Mays var. indurata (Compton's Early)	68.50
Dieffenbachia seguine var. irrorata (cortex)	68.75
Aesculus Hippocastanum	69.00
Dieffenbachia seguine var. irrorata (pith)	69.00
Dieffenbachia seguine var. nobilis (pith)	69.00
Lathyrus magellanicus var. albus	69.00
Dieffenbachia seguine var. nobilis (cortex)	69.00
Maranta Massangeana	69.00
Hyacinthus orientalis var. albulus (White)	69.00
Canna Warscewiczii	69.00
Canna var. (L. E. Baily)	69.00
Brodiaea congesta	69.25
Triteleia uniflora	69.45
Dieffenbachia illustris (pith)	69.50
Canna Roscoeana	69.50
Hyacinthus orientalis var. albulus (Italian)	69.50
Muscari micranthum	69.75
Crocus Susianus (Cloth of Gold)	70.00
Pisum sativum var. (Electric Extra Early)	70.00
Arum cornutum	70.00
Brodiaea coccinea	70.00
Moraea tristis	70.00
Canna var. (Jean Tissot)	70.00
Muscari compactum	70.00
Arisaema triphyllum	70.00
Dieffenbachia illustris (cortex)	70.00
Marica gracilis	70.00
Galanthus Elwesii	70.00
Andropogon Sorghum var. (Yellow Branching Sorghum)	70.00
Canna musaefolia	70.50
Arum palaestinum	70.50
Dieffenbachia seguine var. maculata (pith)	70.50
Pisum sativum var. (Mammoth Gray Seeded)	70.50

	Degrees Centigrade
Dieffenbachia seguine var. maculata (cortex)	70.60
Vicia Gerardi	71.00
Muscari botryoides	71.00
Hedychium Gardnerianum	71.15
Wistaria chinensis	71.50
Sparaxis grandiflora alba	71.50
Hymenocallis undulata	71.50
Leucojum vernum	71.50
Iris florentina	71.50
Hippeastrum aulicum var. robustum	71.75
Iris Bismarckiana	72.00
Antholyza paniculata	72.00
Maranta arundinacea var. No. 2	72.00
Hippeastrum vittatum	72.00
Narcissus Bulbocodium	72.00
Vicia fulgens	72.00
Muscari commutatum	72.00
Arum italicum	72.00
Lens esculenta	72.25
Hedychium coronarium	72.30
Vicia sativa	72.50
Homeria collina	72.50
Hippeastrum equestre	72.50
Sparaxis var. (Albertine)	72.50
Leucojum aestivum	72.50
Maranta arundinacea var. No. 1	72.50
Tritonia Pottsii	72.50
Narcissus Bulbocodium var. conspicuus	72.75
Tritonia crocosmaeflora	73.00
Muscari paradoxum	73.00
Zephyranthes candida	73.00
Muscari conicum	73.00
Lachenalia tricolor var. luteola	73.10
Iris iberica	73.10
Pisum sativum var. (Thomas Laxton)	73.25
Iris pumila var. cyanea	73.25
Narcissus poeticus	73.25
Romulea rosea var. speciosa	73.50
Gelasine azurea	73.50
Pisum sativum var. (Eugenie, yellow)	73.50
Zingiber officinale	73.85
Narcissus Horsfieldii	74.00
Amaryllis belladonna major	74.00
Narcissus Bulbocodium var. monophyllus	74.00
Mucuna pruriens	74.00
Antholyza crocosmoides	74.00
Maranta leuconeura	74.00
Crocus var. (Baron von Brunow)	74.00
Vallota purpurea	74.25

	Degrees Centigrade
Pisum sativum var. (Eugenie, green)	74.50
Phaseolus vulgaris var. (Red Kidney Bean)	74.50
Watsonia iridifolia var. O'Brieni	74.50
Narcissus odorus	74.50
Iris pallida speciosa	74.50
Oryza sativa var.	74.75
Muscari racemosum	74.75
Richardia africana	75.00
Narcissus biflorus	75.00
Crocus versicolor (Cloth of Silver)	75.00
Panicum Crus-galli var.	75.25
Narcissus Jonquilla rugulosus	75.25
Narcissus maximus	75.25
Sternbergia lutea	75.50
Watsonia humilis	75.50
Zephyranthes rosea	76.00
Crinum fimbriatulum	76.00
Narcissus Jonquilla	76.00
Richardia Elliotiana	76.00
Watsonia Meriana	76.25
Narcissus incomparabilis	76.25
Gladiolus cardinalis (Blushing Bride)	76.50
Narcissus Jonquilla Campernelli rugulosus	76.50
Freesia refracta var. alba	76.75
Maranta arundinacea	77.00
Narcissus tazetta var. orientalis	77.00
Sprekelia formosissima	77.00
Crinum americanum	77.00
Freesia refracta var. Leichtlinii	77.25
Richardia albo-maculata	77.50
Gladiolus byzantinus	78.50
Dolichos Lablab	79.50
Phaseolus lunatus var. (Henderson's Bush Lima)	79.75
Haemanthus Katherinae	80.00
Babiana var. violacea	80.00
Gladiolus primulinus	80.50
Tritonia securigera	81.00
Gladiolus floribundus	81.00
Tritonia crocata var. rosea	81.50
Tritonia crocata var. lilacina	81.75
Babiana var. (Athraction)	82.00
Zingiber officinale var. Jamaica No. 1	82.25
Curcuma petiolata	82.50
Tritonia crocata	82.50
Curcuma longa	82.50
Ixia viridiflora	83.00
Ixia speciosa	84.00
Ixia var. (Emma)	84.50
Zingiber officinale var. Jamaica No. 2	85.90
Zingiber officinale var. Cochin	90.00

THE CHLORAL HYDRATE–IODINE REACTIONS OF VARIOUS STARCHES

TABLE F

0-5, zero to five minutes for gelatinization

Zea Mays var. everta (Golden Queen)
Zea Mays var. everta (White Rice)
Pisum sativum var. (Eugenie, yellow)
Pisum sativum var. (Eugenie, green)
Pisum sativum var. (Thos. Laxton)
Wistaria chinensis
Arachis hypogaea
Polygonum Fagopyrum var. (American)
Polygonum Fagopyrum var. (Japanese)
Quercus alba
Quercus Prinus
Quercus rubra
Quercus texana
Castanea americana
Castanea sativa var. numbo
Castanea sativa var.
Castanea pumila
Arum cornutum
Richardia africana
Lilium Parryi
Lilium tigrinum var. splendens
Lilium speciosum var. album
Lilium martagon
Lilium pardalinum
Fritillaria meleagris
Fritillaria pudica
Fritillaria liliacea
Calochortus Benthami
Calochortus lilacina
Calochortus nitidus
Ornithogalum thyrsoides var. aureum
Erythronium Dens-canis
Erythronium Dens-canis var. grand.
Erythronium americanum
Erythronium grandiflorum
Erythronium citrinum
Hyacinthus orientalis var. alba superb.
Hyacinthus orientalis var. albulus (White)
Convallaria majalis
Trillium grandiflorum
Trillium ovatum
Trillium sessile var. californicum
Haemanthus Katherinae
Hymenocallis calathina
Iris florentina
Iris Bismarckiana
Crocus Susianus (Cloth of Gold)
Crocus var. (Baron von Brunow)
Sparaxis grandiflora alba
Sparaxis var. (Albertine)
Musa Cavendishii
Musa Cavendishii (green fruit)
Musa sapientum
Zingiber officinale
Hedychium coronarium
Hedychium Gardnerianum
Canna Warscewiczii
Canna Roscoeana
Canna edulis
Canna var. (Königin Charlotte)
Canna var. (President Carnot)
Canna var. (L. E. Baily)
Canna var. (Mrs. Kate Grey)
Canna var. (Jean Tissot)
Canna var. (J. D. Eisele)
Nelumbo nucifera
Nelumbo lutea
Anemone apennina
Anemone fulgens
Anemone blanda
Anemone japonica
Aconitum Napellus
Actaea alba
Actaea spicata var. rubra
Cimicifuga racemosa
Eranthis hyemalis
Ranunculus bulbosus
Ranunculus Ficaria
Adonis amurensis
Cochlearia Armoracia
Jatropha Curcas
Cyclamen repandum
Cyclamen coum
Gloxinia var.
Trianosperma ficifolia

5-10, five to ten minutes for gelatinization

Zea Mays var. indurata (N. Dakota)
Zea Mays var. indurata (C.'s Early)
Zea Mays var. indentata (E'y L'g)
Zea Mays var. indentata (H. King)
Zea Mays var. saccharata (S.'s E'n)
Zea Mays var. saccharata (B. Mex.)
Zea Mays var. saccharata (G. B'm)
Secale cereale var. (spring)
Avena sativa var. (Clydesdale)
Arrhenatherum elatius var.
Quercus Muhlenbergii
Aesculus Hippocastanum
Arum palaestinum
Dracunculus vulgaris
Richardia albo-maculata
Lilium longiflorum var. eximium
Lilium rubellum
Lilium philadelphicum
Lilium superbum

Lilium tenuifolium
Fritillaria pyrenaica
Fritillaria aurea
Fritillaria armena
Calochortus albus
Calochortus Maweanus var. major
Calochortus Howellii
Calochortus Leichtlinii
Calochortus luteus var. oculatus
Calochortus splendens
Tulipa Hageri
Tulipa Greigi
Tulipa Clusiana
Tulipa Clusiana var. persica
Tulipa oculus-solis
Tulipa australis
Chionodoxa Tmolusi
Puschkinia scilloides
Ornithogalum nutans
Ornithogalum umbellatum
Ornithogalum narbonense (pyramidale)
Erythronium californicum
Galtonia candicans
Amaryllis belladonna major
Sprekelia formosissima
Hymenocallis undulata
Alstroemeria ligtu
Alstroemeria brasiliensis
Tigridia Pavonia var. conchiflora
Crocus versicolor (Cloth of Silver)
Musa ensete
Curcuma longa
Curcuma petiolata
Canna musaefolia

10-15, ten to fifteen minutes for gelatinization

Andropogon Sorghum var. (W. K. Corn)
Andropogon Sorghum var. (Y. B. Sorgh.)
Panicum Crus-galli var.
Dieffenbachia seg. var. nob. (cort.)
Lilium candidum
Lilium longiflorum var. giganteum
Lilium Henryi
Lilium puberulum
Fritillaria imperialis var. Aurora
Fritillaria recurva
Tulipa sylvestris
Tulipa Billietiana
Tulipa Didieri var. Fransoniana
Scilla sibirica
Scilla peruviana
Scilla bifolia
Chionodoxa Lucillae
Chionodoxa sardensis
Puschkinia scilloides var. libanotica
Hyacinthus orient. var. albulus (Italian)
Crinum americanum
Galanthus nivalis
Iris pallida speciosa
Iris pumila var. cyanea
Iris iberica
Iris xiphium var. Grand Tresorier
Iris xiphium var. Wilhelmine
Iris xiphium var. lusitanica
Iris caucasica
Tigridia Pavonia var. grand. alba
Gladiolus floribundus
Watsonia iridifolia var. O'Brieni
Stromanthe sanguinea

15-20, fifteen to twenty minutes for gelatinization

Andropogon Sorghum var. (Shallu)
Oryza sativa
Secale cereale var. (Mammoth Winter)
Richardia Elliotiana
Lilium auratum
Tulipa Didieri
Tulipa Didieri var. mauriana
Tulipa praecox
Muscari botryoides
Muscari micranthum
Alstroemeria aurantiaca (aurea)
Watsonia humilis
Watsonia Meriana

20-25, twenty to twenty-five minutes for gelatinization

Dieffenbachia seg. var. irror. (cort.)
Iris tingitana
Tritonia crocata
Tritonia crocata var. rosea

25-30, twenty-five to thirty minutes for gelatinization

Lathyrus sylvestris
Lathyrus latifolius var. albus
Arum italicum
Arisaema triphyllum
Dieffenbachia seg. var. nob. (pith)
Muscari commutatum
Muscari compactum
Muscari comosum
Lachenalia pendula
Crinum fimbriatulum
Leucojum vernum
Leucojum aestivum
Galanthus Elwesii
Iris alata
Tritonia crocata var. lilacina
Tritonia securigera
Cypella Herberti
Ixia speciosa
Ixia viridiflora
Ixia var. (Emma)
Nymphaea odorata var. rosea

30-35, thirty to thirty-five minutes for gelatinization

Brodiaea candida
Brodiaea laxa

35-40, thirty-five to forty minutes for gelatinization

Dieffenbachia seg. var. irror. (pith)
Iris reticulata

40-45, forty to forty-five minutes for gelatinization

Brodiaea lactea
Lachenalia tricolor var. luteola
Narcissus Jonquilla
Solanum tuberosum

45-50, forty-five to fifty minutes for gelatinization

Muscari racemosum
Colchicum Parkinsoni
Hippeastrum aulicum var. robustum

50-55, fifty to fifty-five minutes for gelatinization

None

55-60, fifty-five to sixty minutes for gelatinization

Triticum sativum var. vulgare
Triticum sativum var. dicoccum
Hordeum sativum var. (Champion)
Vicia sativa
Vicia villosa
Vicia Faba
Vicia fulgens
Vicia Gerardi
Phaseolus vulgaris var. (Red K. Bean)
Phaseolus lunatus var. (H.'s B. Lima)
Dolichos Lablab
Mucuna pruriens
Lens esculenta
Lathyrus odoratus var. Shahzada
Lathyrus magellanicus var. albus
Pisum sativum var. (Elec. E. Early)
Pisum sativum var. (Mam. G. Seeded)
Pisum sativum var. (L. W. Marrowfat)
Dieffenbachia seg. var. mac. (pith)
Dieffenbachia seg. var. mac. (cort.)
Dieffenbachia illustris (pith)
Dieffenbachia illustris (cortex)
Muscari paradoxum
Muscari conicum
Brodiaea peduncularis
Brodiaea ixioides var. splendens
Brodiaea coccinea
Brodiaea grandiflora
Brodiaea californica
Brodiaea Purdyi
Brodiaea stellaris
Brodiaea capitata
Brodiaea congesta
Triteleia uniflora
Hippeastrum vittatum
Hippeastrum equestre
Vallota purpurea
Zephyranthes candida
Zephyranthes rosea
Sternbergia lutea
Narcissus Horsfieldii
Narcissus maximus
Narcissus Bulbocodium
Narcissus Bulbocodium var. conspicuus
Narcissus Bulbocodium var. monophyllus
Narcissus incomparabilis
Narcissus odorus
Narcissus poeticus
Narcissus biflorus
Narcissus Jonquilla var. rugulosus
Narcissus Jonquilla var. Campernelli rug.
Narcissus tazetta var. orientalis
Tacca pinnatifida
Iris Histrio
Moraea tristis
Homeria collina
Gladiolus byzantinus
Gladiolus primulinus
Gladiolus cardinalis (Blushing Bride)
Tritonia Pottsii
Tritonia crocosmaeflora
Freesia refracta var. alba
Freesia refracta var. Leichtlinii
Antholyza crocosmoides
Antholyza paniculata
Romulea rosea var. speciosa
Marica gracilis
Gelasine azurea
Babiana var. (violacea)
Babiana var. (Athraction)
Zingiber officinale var. Jamaica No. 1
Zingiber officinale var. Jamaica No. 2
Zingiber officinale var. Cochin
Maranta arundinacea
Maranta arundinacea var. No. 1
Maranta arundinacea var. No. 2
Maranta Massangeana
Maranta leuconeura
Maranta musaica
Calathea Lietzei
Calathea vittata
Calathea Wiotiana
Calathea Vandenheckei
Nymphaea alba
Nymphaea marliacea var. albida
Nymphaea marliacea var. carnea
Nymphaea Gladstoniana

Nymphaea odorata
Manihot utilissima
Batatas edulis
Gesneria tubiflora
Cycas revoluta
Cycas circinalis
Dioon edule
Zamia integrifolia

THE CHROMIC ACID REACTIONS OF VARIOUS STARCHES

TABLE G

0-1, zero to one minute for gelatinization

Zea Mays var. indentata (H. King)
Zea Mays var. saccharata (B. Mex.)
Avena sativa var. (Clydesdale)
Arrhenatherum elatius var.
Wistaria chinensis
Polygonum Fagopyrum var. (American)
Polygonum Fagopyrum var. (Japanese)
Quercus alba
Quercus Muhlenbergii
Quercus rubra
Quercus texana
Castanea americana
Castanea sativa var. numbo
Castanea sativa var.
Castanea pumila
Aesculus Hippocastanum
Lilium candidum
Lilium longiflorum var. giganteum
Lilium longiflorum var. eximium
Lilium Parryi
Lilium rubellum
Lilium philadelphicum
Lilium tigrinum var. splendens
Lilium Henryi
Lilium speciosum var. album
Lilium martagon
Lilium superbum
Lilium tenuifolium
Lilium pardalinum
Lilium puberulum
Fritillaria meleagris
Fritillaria pyrenaica
Fritillaria pudica
Fritillaria aurea
Fritillaria armena
Fritillaria imperialis var. Aurora
Fritillaria liliacea
Fritillaria recurva
Calochortus albus
Calochortus Maweanus var. major
Calochortus lilacinus
Calochortus nitidus
Calochortus Howellii
Calochortus Leichtlinii
Calochortus luteus var. oculatus
Calochortus splendens
Tulipa Hageri
Tulipa sylvestris
Tulipa Greigi
Tulipa Billietiana
Tulipa Didieri
Tulipa Didieri var. mauriana
Tulipa Didieri var. Fransoniana
Tulipa Clusiana
Tulipa Clusiana var. persica
Tulipa oculus-solis
Tulipa praecox
Tulipa australis
Scilla sibirica
Puschkinia scilloides
Puschkinia scilloides var. libanotica
Ornithogalum nutans
Ornithogalum umbellatum
Ornithogalum narbonense (pyramidale)
Erythronium Dens-canis
Erythronium Dens-canis var. grand.
Erythronium americanum
Erythronium grandiflorum
Erythronium citrinum
Erythronium californicum
Galtonia candicans
Convallaria majalis
Trillium grandiflorum
Trillium ovatum
Trillium sessile var. californicum
Alstroemeria ligtu
Alstroemeria brasiliensis
Iris florentina
Iris Bismarckiana
Iris xiphium var. Grand Tresorier
Tigridia Pavonia var. grand. alba
Tigridia Pavonia var. conchiflora
Crocus Susianus (Cloth of Gold)
Sparaxis var. (Albertine)
Musa ensete
Nymphaea marliacea var. carnea
Nelumbo lutea
Anemone apennina
Anemone fulgens
Anemone blanda
Anemone japonica
Aconitum Napellus
Actaea alba
Actaea spicata var. rubra
Cimicifuga racemosa
Eranthis hyemalis
Ranunculus bulbosus

Ranunculus Ficaria
Adonis amurensis
Cochlearia Armoracia
Jatropha Curcas
Cyclamen repandum
Cyclamen coum
Gloxinia var.

1-2, one to two minutes for gelatinization

Zea Mays var. everta (Golden Queen)
Zea Mays var. everta (White Rice)
Zea Mays var. saccharata (G. B'm)
Panicum Crus-galli var.
Triticum sativum var. dicoccum
Secale cereale var. (Spring)
Vicia Gerardi
Lathyrus sylvestris
Arachis hypogaea
Quercus Prinus
Dieffenbachia seg. var. irror. (cort.)
Lilium auratum
Calochortus Benthami
Scilla peruviana
Scilla bifolia
Chionodoxa Lucillae
Chionodoxa Tmolusi
Chionodoxa sardensis
Ornithogalum thyrsoides var. aureum
Hyacinthus orientalis var. albus superb.
Muscari micranthum
Muscari commutatum
Brodiaea laxa
Colchicum Parkinsoni
Galanthus nivalis
Alstroemeria aurantiaca (aurea)
Iris pallida speciosa
Iris iberica
Iris xiphium var. Wilhelmine
Iris xiphium var. lusitanica
Iris reticulata
Iris caucasica
Antholyza paniculata
Crocus var. (Baron von Brunow)
Sparaxis grandiflora alba
Ixia speciosa
Ixia viridiflora
Ixia var. (Emma)
Babiana var. (violacea)
Babiana var. (Athraction)
Musa sapientum
Zingiber officinale
Canna Warscewiczii
Canna var. (Königin Charlotte)
Canna var. (President Carnot)
Canna var. (L. E. Baily)
Canna var. (Mrs. Kate Grey)
Canna var. (J. D. Eisele)
Maranta arundinacea var. No. 1
Maranta arundinacea var. No. 2
Maranta leuconeura
Nymphaea alba
Nymphaea odorata var. rosea
Nelumbo nucifera
Manihot utilissima
Trianosperma ficifolia
Dioon edule

2-3, two to three minutes for gelatinization

Zea Mays var. saccharata (S.'s E'n)
Andropogon Sorghum var. (W. K. Corn)
Andropogon Sorghum var. (Shallu)
Triticum sativum var. vulgare
Secale cereale var. (Mammoth Winter)
Hordeum sativum var. (Champion)
Vicia villosa
Vicia Faba
Vicia fulgens
Pisum sativum var. (Eugenie, green)
Hyacinthus orientalis var. albulus (White)
Hyacinthus orientalis var. albulus (Italian)
Muscari racemosum
Muscari compactum
Muscari comosum
Amaryllis belladonna major
Hymenocallis calathina
Iris pumila var. cyanea
Iris tingitana
Iris alata
Watsonia iridifolia var. O'Brieni
Freesia refracta var. Leichtlinii
Antholyza crocosmoides
Crocus versicolor (Cloth of Silver)
Cypella Herberti
Musa Cavendishii (green fruit)
Canna Roscoeana
Canna edulis
Canna var. (Jean Tissot)
Maranta Massangeana
Nymphaea Gladstoniana
Nymphaea odorata

3-4, three to four minutes for gelatinization

Zea Mays var. indurata (N. Dakota)
Zea Mays var. indurata (C.'s Early)
Andropogon Sorghum var. (Y. B. Sorgh.)
Oryza sativa var.
Lathyrus latifolius var. albus
Pisum sativum var. (Mam. G. Seeded)
Richardia africana
Dieffenbachia seg. var. nob. (pith)
Dieffenbachia seg. var. nob. (cort.)
Dieffenbachia seg. irror. (pith)
Dieffenbachia illustris (pith)
Dieffenbachia illustris (cortex)

Muscari botryoides
Muscari paradoxum
Muscari conicum
Brodiaea candida
Brodiaea lactea
Triteleia uniflora
Leucojum vernum
Narcissus Jonquilla var. rugulosus
Tacca pinnatifida
Iris Histrio
Moraea tristis
Gladiolus cardinalis (Blushing Bride)
Gladiolus floribundus
Tritonia Pottsii
Tritonia crocosmaeflora
Freesia refracta var. alba
Romulea rosea var. speciosa
Canna musaefolia
Maranta arundinacea
Nymphaea marliacea var. albida
Cycas circinalis

4-5, four to five minutes for gelatinization

Vicia sativa
Lathyrus magellanicus var. albus
Pisum sativum var. (Thos. Laxton)
Pisum sativum var. (L. W. Marrowfat)
Arum italicum
Arisaema triphyllum
Richardia Elliotiana
Dieffenbachia seg. var. mac. (cort.)
Brodiaea congesta
Lachenalia pendula
Vallota purpurea
Hymenocallis undulata
Leucojum aestivum
Narcissus maximus
Narcissus Bulbocodium var. monophyllus
Narcissus odorus
Narcissus biflorus
Gladiolus primulinus
Watsonia humilis
Watsonia Meriana
Musa Cavendishii
Hedychium Gardnerianum
Calathea vittata
Calathea Vandenheckei
Stromanthe sanguinea
Gesneria tubiflora
Cycas revoluta

5-6, five to six minutes for gelatinization

Pisum sativum var. (Eugenie, yellow)
Pisum sativum var. (Elec. E. Early)
Arum cornutum
Dieffenbachia seg. var. mac. (pith)
Brodiaea ixioides var. splendens
Brodiaea coccinea
Hippeastrum vittatum
Hippeastrum equestre
Hippeastrum aulicum var. robustum
Zephyranthes candida
Zephyranthes rosea
Narcissus Bulbocodium var. conspicuus
Nacissus incomparabilis
Marica gracilis
Calathea Lietzei
Calathea Wiotiana
Solanum tuberosum
Zamia integrifolia

6-7, six to seven minutes for gelatinization

Dolichos Lablab
Mucuna pruriens
Dracunculus vulgaris
Haemanthus Katherinae
Sternbergia lutea
Narcissus Jonquilla var. Campernelli rug.
Gladiolus byzantinus
Batalas edulis

7-8, seven to eight minutes for gelatinization

Phaseolus vulgaris var. (Red K. Bean)
Phaseolus lunatus var. (H.'s B. Lima)
Galanthus Elwesii
Narcissus Bulbocodium
Narcissus tazetta var. orientalis
Maranta musaica

8-9, eight to nine minutes for gelatinization

Narcissus poeticus
Curcuma petiolata

9-10, nine to ten minutes for gelatinization

Lathyrus odoratus var. Shahzada
Arum palaestinum
Richardia albo-maculata
Brodiaea peduncularis
Brodiaea grandiflora
Brodiaea Purdyi
Brodiaea stellaris
Brodiaea capitata
Crinum americanum
Sprekelia formosissima
Narcissus Jonquilla
Curcuma longa

10-11, ten to eleven minutes for gelatinization

Zingiber officinale var. Cochin
Hedychium coronarium

11-12, eleven to twelve minutes for gelatinization

Gelasine azurea

12-13, twelve to thirteen minutes for gelatinization

Lens esculenta

Zingiber officinale var. Jamaica, No. 2

13-, thirteen or more minutes for gelatinization

Crinum fimbriatulum
Narcissus Horsfieldii
Homeria collina
Tritonia crocata
Tritonia crocata var. lilacina
Tritonia crocata var. rosea
Tritonia securigera
Zingiber officinale var. Jamaica, No. 1

THE PYROGALLIC ACID REACTIONS OF VARIOUS STARCHES

TABLE H

0-5, zero to five minutes for gelatinization

Zea Mays var. everta (Golden Queen)
Zea Mays var. everta (White Rice)
Zea Mays var. indurata (N. Dakota)
Zea Mays var. indurata (C.'s Early)
Zea Mays var. indentata (E'y L'g)
Zea Mays var. indentata (H. King)
Zea Mays var. saccharata (S.'s E'n)
Zea Mays var. saccharata (B. Mex.)
Zea Mays var. saccharata (G. B'm)
Andropogon Sorghum var. (W. K. Corn)
Andropogon Sorghum var. (Y. B. Sorgh.)
Andropogon Sorghum var. (Shallu)
Triticum sativum var. vulgare
Triticum sativum var. dicoccum
Secale cereale var. (Mammoth Winter)
Secale cereale var. (Spring)
Hordeum sativum var. (Champion)
Avena sativa var. (Clydesdale)
Arrhenatherum elatius var.
Vicia sativa
Vicia villosa
Vicia fulgens
Vicia Gerardi
Phaseolus vulgaris var. (Red K. Bean)
Phaseolus lunatus var. (H.'s B. Lima)
Lens esculenta
Lathyrus odoratus var. Shahzada
Lathyrus sylvestris
Lathyrus latifolius var. albus
Lathyrus magellanicus var. albus
Pisum sativum var. (Elec. E. Early)
Pisum sativum var. (Mam. G. Seeded)
Pisum sativum var. (L. W. Marrowfat)
Arachis hypogaea
Polygonum Fagopyrum var. (American)
Polygonum Fagopyrum var. (Japanese)
Quercus alba
Quercus Prinus
Quercus rubra
Quercus texana
Castanea americana
Castanea sativa var. numbo
Castanea sativa var.
Castanea pumila
Aesculus Hippocastanum
Dieffenbachia seg. var. nob. (pith)
Dieffenbachia seg. var. nob. (cort.)
Lilium candidum
Lilium longiflorum var. giganteum
Lilium longiflorum var. eximium
Lilium Parryi
Lilium rubellum
Lilium philadelphicum
Lilium tigrinum var. splendens
Lilium Henryi
Lilium auratum
Lilium speciosum var. album
Lilium martagon
Lilium superbum
Lilium tenuifolium
Lilium pardalinum
Lilium puberulum
Fritillaria meleagris
Fritillaria pyrenaica
Fritillaria pudica
Fritillaria aurea
Fritillaria armena
Fritillaria imperialis var. Aurora
Fritillaria liliacea
Fritillaria recurva
Calochortus albus
Calochortus Benthami
Calochortus lilacinus
Calochortus nitidus
Calochortus Howellii
Calochortus splendens
Tulipa Hageri
Tulipa sylvestris
Tulipa Greigi

Tulipa Billietiana
Tulipa Didieri
Tulipa Didieri var. mauriana
Tulipa Didieri var. Fransoniana
Tulipa Clusiana
Tulipa Clusiana var. persica
Tulipa oculus-solis
Tulipa praecox
Tulipa australis
Scilla sibirica
Scilla peruviana
Scilla bifolia
Chionodoxa Lucillae
Chionodoxa Tmolusi
Chionodoxa sardensis
Puschkinia scilloides
Puschkinia scilloides var. libanotica
Ornithogalum umbellatum
Ornithogalum narbonense (pyramidale)
Ornithogalum thyrsoides var. aureum
Erythronium Dens-canis
Erythronium Dens-canis var. grand.
Erythronium americanum
Erythronium grandiflorum
Erythronium citrinum
Erythronium californicum
Hyacinthus orientalis var. albus superb.
Hyacinthus orientalis var. albulus (White)
Hyacinthus orientalis var. albulus (Italian)
Galtonia candicans
Muscari botryoides
Muscari compactum
Brodiaea ixioides var. splendens
Brodiaea candida
Brodiaea lactea
Brodiaea laxa
Triteleia uniflora
Lachenalia pendula
Lachenalia tricolor var. luteola
Convallaria majalis
Trillium grandiflorum
Trillium ovatum
Trillium sessile var. californicum
Colchicum Parkinsoni
Amaryllis belladonna major
Crinum fimbriatulum
Crinum americanum
Sprekelia formosissima
Haemanthus Katherinae
Hymenocallis undulata
Hymenocallis calathina
Leucojum vernum
Leucojum aestivum
Alstroemeria ligtu
Alstroemeria brasiliensis
Alstroemeria aurantiaca (aurea)
Tacca pinnatifida
Iris florentina
Iris pallida speciosa
Iris pumila var. cyanea
Iris Bismarckiana
Iris iberica
Iris xiphium var. Grand Tresorier
Iris xiphium var. Wilhelmine
Iris xiphium var. lusitanica
Iris tingitana
Iris reticulata
Iris Histrio
Iris alata
Iris caucasica
Tigridia Pavonia var. grand. alba
Tigridia Pavonia var. conchiflora
Antholyza crocosmoides
Antholyza paniculata
Crocus Susianus (Cloth of Gold)
Crocus versicolor (Cloth of Silver)
Crocus var. (Baron von Brunow)
Cypella Herberti
Marica gracilis
Sparaxis grandiflora alba
Sparaxis var. (Albertine)
Maranta arundinacea
Maranta arundinacea var. No. 1
Maranta arundinacea var. No. 2
Maranta Massangeana
Maranta leuconeura
Maranta musaica
Nymphaea alba
Nymphaea marliacea var. carnea
Nymphaea odorata
Nymphaea odorata var. rosea
Nelumbo nucifera
Nelumbo lutea
Anemone apennina
Anemone fulgens
Anemone blanda
Anemone japonica
Aconitum Napellus
Actaea alba
Actaea spicata var. rubra
Cimicifuga racemosa
Eranthis hyemalis
Ranunculus bulbosus
Ranunculus Ficaria
Adonis amurensis
Cochlearia Armoracia
Jatropha Curcas
Manihot utilissima
Cyclamen repandum
Cyclamen coum
Gloxinia var.
Trianosperma ficifolia
Dioon edule

5-10, five to ten minutes for gelatinization
Panicum Crus-galli var.
Oryza sativa var.
Vicia Faba
Wistaria chinensis
Arum italicum

Dieffenbachia seg. var. mac. (pith)
Dieffenbachia seg. var. mac. (cort.)
Dieffenbachia seg. var. irror. (pith)
Dieffenbachia seg. var. irror. (cort.)
Dieffenbachia illustris (pith)
Calochortus Maweanus var. major
Calochortus Leichtlinii
Calochortus luteus var. oculatus
Ornithogalum nutans
Muscari micranthum
Muscari comosum
Brodiaea peduncularis
Watsonia iridifolia var. O'Brieni
Ixia speciosa
Babiana var. (Athraction)
Stromanthe sanguinea
Nymphaea marliacea var. albida
Nymphaea Gladstoniana
Zamia integrifolia

10-15, ten to fifteen minutes for gelatinization

Mucuna pruriens
Arum palaestinum
Dracunculus vulgaris
Dieffenbachia illustris (cortex)
Galanthus nivalis
Narcissus Bulbocodium var. monophyllus
Narcissus Jonquilla var. rugulosus
Gladiolus floribundus
Watsonia humilis
Watsonia Meriana
Tritonia Pottsii
Tritonia crocosmaeflora
Musa ensete
Canna var. (President Carnot)
Canna var. (Jean Tissot)
Canna var. (J. D. Eisele)

15-20, fifteen to twenty minutes for gelatinization

Dolichos Lablab
Muscari paradoxum
Hippeastrum aulicum var. robustum
Narcissus Bulbocodium var. conspicuus
Ixia viridiflora
Ixia var. (Emma)
Babiana var. (violacea)
Canna edulis
Canna var. (Mrs. Kate Grey)
Calathea vittata

20-25, twenty to twenty-five minutes for gelatinization

Arisaema triphyllum
Muscari commutatum
Vallota purpurea
Sternbergia lutea
Narcissus biflorus
Gladiolus cardinalis (Blushing Bride)
Zingiber officinale var. Cochin
Solanum tuberosum
Cycas circinalis

25-30, twenty-five to thirty minutes for gelatinization

Arum cornutum
Muscari racemosum
Hippeastrum vittatum
Zephyranthes rosea
Narcissus incomparabilis
Gladiolus byzantinus
Curcuma longa
Canna var. (L. E. Baily)
Gesneria tubiflora
Cycas revoluta

30-35, thirty to thirty-five minutes for gelatinization

Muscari conicum
Hippeastrum equestre
Zephyranthes candida
Narcissus maximus
Gladiolus primulinus

35-40, thirty-five to forty minutes for gelatinization

Brodiaea stellaris
Canna var. (Königin Charlotte)

40-45, forty to forty-five minutes for gelatinization

Brodiaea californica
Galanthus Elwesii
Narcissus Bulbocodium
Musa Cavendishii
Musa Cavendishii (green fruit)
Musa sapientum
Batatas edulis

45-50, forty-five to fifty minutes for gelatinization

None

50-55, fifty to fifty-five minutes for gelatinization

None

55-60, fifty-five to sixty minutes for gelatinization

Pisum sativum var. (Eugenie, yellow)
Pisum sativum var. (Eugenie, green)
Pisum sativum var. (Thos. Laxton)
Richardia Elliotiana
Richardia africana
Richardia albo-maculata
Brodiaea coccinea
Brodiaea grandiflora
Brodiaea Purdyi
Brodiaea capitata

Brodiaea congesta
Narcissus Horsfieldii
Narcissus odorus
Narcissus poeticus
Narcissus Jonquilla
Narcissus Jonquilla var. Campernelli rug.
Narcissus tazetta var. orientalis
Moraea tristis
Homeria collina
Tritonia crocata
Tritonia crocata var. lilacina
Tritonia crocata var. rosea
Tritonia securigera
Freesia refracta var. alba
Freesia refracta var. Leichtlinii
Romulea rosea var. speciosa
Gelasine azurea
Zingiber officinale
Zingiber officinale var. Jamaica No. 1
Zingiber officinale var. Jamaica No. 2
Hedychium coronarium
Hedychium Gardnerianum
Curcuma petiolata
Canna Warscewiczii
Canna Roscoeana
Canna musaefolia
Calathea Lietzei
Calathea Wiotiana
Calathea Vandenheckei

THE FERRIC CHLORIDE REACTION OF VARIOUS STARCHES

TABLE I

0-5, zero to five minutes for gelatinization

Castanea americana
Castanea sativa var. numbo
Castanea sativa var.
Castanea pumila
Aesculus Hippocastanum
Calochortus Benthami
Calochortus lilacinus
Calochortus nitidus
Calochortus Howellii
Tulipa Hageri
Tulipa Clusiana
Tulipa australis
Erythronium Dens-canis
Erythronium Dens-canis var. grand.
Erythronium americanum
Erythronium grandiflorum
Erythronium citrinum
Erythronium californicum
Galtonia candicans
Convallaria majalis
Trillium grandiflorum
Trillium ovatum
Iris Bismarckiana
Sparaxis grandiflora alba
Sparaxis var. (Albertine)
Musa Cavendishii (green fruit)
Zingiber officinale
Hedychium Gardnerianum
Maranta arundinacea
Anemone apennina
Anemone fulgens
Anemone blanda
Anemone japonica
Aconitum Napellus
Actaea alba
Cimicifuga racemosa
Ranunculus bulbosus
Ranunculus Ficaria
Adonis amurensis
Cochlearia Armoracia
Cyclamen repandum
Cyclamen coum
Batatas edulis
Trianosperma ficifolia

5-10, five to ten minutes for gelatinization

Zea Mays var. everta (Golden Queen)
Zea Mays var. everta (White Rice)
Zea Mays var. indentata (H. King)
Zea Mays var. saccharata (S.'s E'n)
Zea Mays var. saccharata (G. B'm)
Oryza sativa var.
Avena sativa var. (Clydesdale)
Arrhenatherum elatius var.
Arum italicum
Dieffenbachia seg. var. nob. (cort.)
Lilium longiflorum var. eximium
Lilium tigrinum var. splendens
Lilium auratum
Lilium superbum
Fritillaria pyrenaica
Fritillaria aurea
Fritillaria armena
Calochortus albus
Calochortus Maweanus var. major
Calochortus Leichtlinii
Calochortus luteus var. oculatus
Calochortus splendens
Tulipa sylvestris
Tulipa Greigi
Tulipa Billietiana
Tulipa Didieri
Tulipa Didieri var. mauriana
Tulipa oculus-solis
Tulipa praecox

Chionodoxa Tmolusi
Chionodoxa sardensis
Ornithogalum narbonense (pyramidale)
Hyacinthus orientalis var. albus superb.
Hyacinthus orientalis var. albulus (White)
Trillium sessile var. californicum
Iris florentina
Iris xiphium var. Wilhelmine
Crocus Susianus (Cloth of Gold)
Ixia speciosa
Musa Cavendishii
Musa sapientum
Musa ensete
Hedychium coronarium
Curcuma longa
Curcuma petiolata
Canna Roscoeana
Maranta arundinacea var. No. 1
Maranta leuconeura
Nelumbo lutea
Actaea spicata var. rubra
Eranthus hyemalis
Gesneria tubiflora
Gloxinia var.
Dioon edule

10-15, ten to fifteen minutes for gelatinization

Zea Mays var. indurata (N. Dakota)
Zea Mays var. indurata (C.'s Early)
Zea Mays var. indentata (E'y L'g)
Andropogon Sorghum var. (Y. B. Sorgh.)
Andropogon Sorghum var. (Shallu)
Arachis hypogaea
Quercus rubra
Quercus texana
Arum cornutum
Dieffenbachia seg. var. irror. (pith)
Lilium Parryi
Lilium philadelphicum
Lilium martagon
Fritillaria meleagris
Fritillaria imperialis var. Aurora
Fritillaria liliacea
Fritillaria recurva
Tulipa Didieri var. Fransoniana
Tulipa Clusiana var. persica
Scilla sibirica
Ornithogalum nutans
Ornithogalum umbellatum
Ornithogalum thyrsoides var. aureum
Hyacinthus orient. var. albulus (Italian)
Muscari micranthum
Alstroemeria ligtu
Alstroemeria brasiliensis
Iris pallida speciosa
Iris pumila var. cyanea
Iris iberica
Iris xiphium var. Grand Tresorier
Iris xiphium var. lusitanica
Tigridia Pavonia var. grand. alba
Tigridia Pavonia var. conchiflora
Crocus versicolor (Cloth of Silver)
Crocus var. (Baron von Brunow)
Ixia iridiflora
Babiana var. (violacea)
Canna Warscewiczii
Canna var. (President Carnot)
Maranta arundinacea var. No. 2
Maranta Massangeana
Calathea Lietzei
Nymphaea alba
Nelumbo nucifera

15-20, fifteen to twenty minutes for gelatinization

Andropogon Sorghum var. (W. K. Corn)
Wistaria chinensis
Polygonum Fagopyrum var. (Japanese)
Dieffenbachia seg. var. nob. (pith)
Dieffenbachia illustris (cortex)
Lilium longiflorum var. giganteum
Lilium rubellum
Lilium speciosum var. album
Lilium tenuifolium
Lilium pardalinum
Lilium puberulum
Fritillaria pudica
Scilla peruviana
Scilla bifolia
Puschkinia scilloides
Puschkinia scilloides var. libanotica
Lachenalia pendula
Lachenalia tricolor var. luteola
Amaryllis belladonna major
Alstroemeria aurantiaca (aurea)
Iris tingitana
Ixia var. (Emma)
Babiana var. (Athraction)
Canna var. (Königin Charlotte)
Canna var. (Mrs. Kate Grey)
Canna var. (J. D. Eisele)
Nymphaea odorata
Jatropha Curcas
Manihot utilissima

20-25, twenty to twenty-five minutes for gelatinization

Panicum Crus-galli var.
Dieffenbachia seg. var. mac. (pith)
Dieffenbachia seg. var. mac. (cort.)
Lilium candidum
Muscari racemosum
Brodiaea coccinea
Sprekelia formosissima
Gladiolus primulinus
Gladiolus floribundus

Antholyza paniculata
Canna musaefolia
Canna var. (L. E. Baily)
Canna var. (Jean Tissot)
Nymphaea marliacea var. carnea
Solanum tuberosum
Cycas revoluta
Cycas circinalis

25-30, twenty-five to thirty minutes for gelatinization

Pisum sativum var. (Eugenie, yellow)
Pisum sativum var. (Eugenie, green)
Pisum sativum var. (Thos. Laxton)
Quercus alba
Quercus Prinus
Arum palaestinum
Arisaema triphyllum
Dieffenbachia seg. var. mac. (cort.)
Dieffenbachia illustris (pith)
Lilium Henryi
Chionodoxa Lucillae
Brodiaea candida
Colchicum Parkinsoni
Crinum americanum
Hymenocallis calathina
Iris alata
Freesia refracta var. alba
Freesia refracta var. Leichtlinii
Cypella Herberti

30-35, thirty to thirty-five minutes for gelatinization

Polygonum Fagopyrum var. (American)
Richardia Elliotiana
Muscari commutatum
Muscari compactum
Muscari comosum
Tacca pinnatifida
Iris reticulata
Tritonia securigera
Stromanthe sanguinea
Nymphaea odorata var. rosea

35-40, thirty-five to forty minutes for gelatinization

Vicia villosa
Richardia africana
Muscari botryoides
Brodiaea lactea
Hippeastrum aulicum var. robustum
Zephyranthes candida
Narcissus Jonquilla
Narcissus Jonquilla var. rugulosus
Iris caucasica
Watsonia humilis
Tritonia crocata
Tritonia Pottsii
Antholyza crocosmoides

40-45, forty to forty-five minutes for gelatinization

Vicia Gerardi
Quercus Muhlenbergii
Dracunculus vulgaris
Muscari paradoxum
Brodiaea laxa
Narcissus Bulbocodium
Narcissus Bulbocodium var. monophyllus
Narcissus incomparabilis
Narcissus Jonquilla var. Campernelli rug.
Moraea tristis
Gladiolus byzantinus
Gladiolus cardinalis (Blushing Bride)
Watsonia iridifolia var. O'Brieni
Watsonia Meriana
Tritonia crocata var. rosea
Tritonia crocosmaeflora
Marica gracilis
Zingiber officinale var. Jamaica No. 2
Canna edulis
Nymphaea Gladstoniana

45-50, forty-five to fifty minutes for gelatinization

Brodiaea ixioides var. splendens
Hippeastrum equestre
Zephyranthes rosea
Haemanthus Katherinae
Narcissus odorus
Iris Histrio
Nymphaea marliacea var. albida

50-55, fifty to fifty-five minutes for gelatinization

Triteleia uniflora
Hippeastrum vittatum
Vallota purpurea
Zingiber officinale var. Cochin

55-60, fifty-five to sixty minutes for gelatinization

Triticum sativum var. vulgare
Triticum sativum var. dicoccum
Secale cereale var. (Mammoth Winter)
Secale cereale var. (Spring)
Hordeum sativum var. (Champion)
Vicia sativa
Vicia Faba
Vicia fulgens
Phaseolus vulgaris var. (Red K. Bean)
Phaseolus lunatus var. (H.'s B. Lima)
Dolichos Lablab
Mucuna pruriens
Lens esculenta
Lathyrus odoratus var. Shahzada
Lathyrus sylvestris
Lathyrus latifolius var. albus

Lathyrus magellanicus var. albus
Pisum sativum var. (Elec. E. Early)
Pisum sativum var. (Mam. G. Seeded)
Pisum sativum var. (L. W. Marrowfat)
Richardia albo-maculata
Muscari conicum
Brodiaea peduncularis
Brodiaea grandiflora
Brodiaea californica
Brodiaea Purdyi
Brodiaea stellaris
Brodiaea capitata
Brodiaea congesta
Crinum fimbriatulum
Hymenocallis undulata
Leucojum vernum
Leucojum aestivum
Galanthus nivalis
Sternbergia lutea
Narcissus Horsfieldii
Narcissus maximus
Narcissus Bulbocodium var. conspicuus
Narcissus poeticus
Narcissus biflorus
Narcissus tazetta var. orientalis
Homeria collina
Tritonia crocata var. lilacina
Romulea rosea var. speciosa
Gelasine azurea
Zingiber officinale var. Jamaica, No. 1
Maranta musaica
Calathea vittata
Calathea Wiotiana
Calathea Vandenheckei
Zamia integrifolia

THE PURDY'S SOLUTION REACTIONS OF VARIOUS STARCHES

TABLE J

0-5, zero to five minutes for gelatinization
Quercus alba
Castanea americana
Castanea sativa var. numbo
Castanea sativa var.
Castanea pumila
Lilium candidum
Lilium longiflorum var. giganteum
Lilium longiflorum var. eximium
Lilium Parryi
Lilium rubellum
Lilium philadelphicum
Lilium tigrinum var. splendens
Lilium Henryi
Lilium auratum
Lilium speciosum var. album
Lilium martagon
Lilium superbum
Lilium tenuifolium
Lilium pardalinum
Lilium puberulum
Fritillaria meleagris
Fritillaria pyrenaica
Fritillaria pudica
Fritillaria aurea
Fritillaria armena
Fritillaria liliacea
Fritillaria recurva
Calochortus albus
Calochortus Maweanus var. major
Calochortus Benthami
Calochortus lilacinus
Calochortus nitidus
Calochortus Howellii
Calochortus Leichtlinii
Calochortus luteus var. oculatus
Calochortus splendens
Tulipa Hageri
Tulipa sylvestris
Tulipa Greigi
Tulipa Billietiana
Tulipa Didieri
Tulipa Didieri var. mauriana
Tulipa Didieri var. Fransoniana
Tulipa Clusiana
Tulipa Clusiana var. persica
Tulipa oculus-solis
Tulipa praecox
Tulipa australis
Scilla peruviana
Scilla bifolia
Chionodoxa Lucillae
Chionodoxa sardensis
Ornithogalum nutans
Ornithogalum umbellatum
Ornithogalum narbonense (pyramidale)
Erythronium Dens-canis
Erythronium Dens-canis var. grand.
Erythronium americanum
Erythronium grandiflorum
Erythronium citrinum
Erythronium californicum
Galtonia candicans
Convallaria majalis
Alstroemeria ligtu
Alstroemeria brasiliensis
Alstroemeria aurantiaca (aurea)
Iris Histrio
Sparaxis grandiflora alba

Sparaxis var. (Albertine)
Zingiber officinale
Curcuma longa
Curcuma petiolata
Maranta arundinacea
Maranta arundinacea var. No. 1
Maranta arundinacea var. No. 2
Maranta leuconeura
Nelumbo lutea
Anemone apennina
Anemone fulgens
Anemone blanda
Anemone japonica
Aconitum Napellus
Actaea alba
Actaea spicata var. rubra
Cimicifuga racemosa
Eranthis hyemalis
Adonis amurensis
Cochlearia Armoracia
Gloxinia var.
Trianosperma ficifolia
Dioon edule

5-10, five to ten minutes for gelatinization

Fritillaria imperialis var. Aurora
Chionodoxa Tmolusi
Ornithogalum thyrsoides var. aureum
Trillium grandiflorum
Iris caucasica
Ixia speciosa
Babiana var. (Athraction)
Musa Cavendishii (green fruit)
Musa sapientum
Musa ensete
Zingiber officinale var. Jamaica, No. 1
Zingiber officinale var. Jamaica, No. 2
Zingiber officinale var. Cochin
Canna var. (President Carnot)
Maranta Massangeana
Maranta musaica
Calathea vittata
Calathea Wiotiana
Ranunculus bulbosus
Jatropha Curcas
Cyclamen repandum

10-15, ten to fifteen minutes for gelatinization

Triticum sativum var. dicoccum
Vicia Faba
Scilla sibirica
Puschkinia scilloides
Trillium ovatum
Amaryllis belladonna major
Iris reticulata
Iris alata
Ixia viridiflora
Musa Cavendishii
Canna Roscoeana
Canna var. (Königin Charlotte)
Canna var. (Mrs. Kate Grey)
Canna var. (J. D. Eisele)
Nymphaea alba
Nymphaea odorata var. rosea
Cyclamen coum
Solanum tuberosum
Gesneria tubiflora

15-20, fifteen to twenty minutes for gelatinization

Vicia villosa
Arachis hypogaea
Aesculus Hippocastanum
Puschkinia scilloides var. libanotica
Tigridia Pavonia var. conchiflora
Ixia var. (Emma)
Babiana var. (violacea)
Canna musaefolia
Canna edulis
Canna var. (Jean Tissot)
Calathea Lietzei
Stromanthe sanguinea
Nelumbo nucifera

20-25, twenty to twenty-five minutes for gelatinization

Triticum sativum var. vulgare
Vicia Gerardi
Trillium sessile var. californicum
Tigridia Pavonia var. grand. alba
Canna Warscewiczii
Canna var. (L. E. Baily)
Nymphaea marliacea var. carnea
Nymphaea odorata
Manihot utilissima

25-30, twenty-five to thirty minutes for gelatinization

Lathyrus sylvestris
Lathyrus latifolius var. albus
Pisum sativum var. (Eugenie, yellow)
Pisum sativum var. (Eugenie, green)
Pisum sativum var. (Thos. Laxton)
Quercus Prinus
Hyacinthus orientalis var. albus superb.
Crocus Susianus (Cloth of Gold)
Ranunculus Ficaria

30-35, thirty to thirty-five minutes for gelatinization

None

35-40, thirty-five to forty minutes for gelatinization

Calathea Vandenheckei
Cycas circinalis

40-45, forty to forty-five minutes for gelatinization

Hedychium coronarium
Hedychium Gardnerianum

45-50, forty-five to fifty minutes for gelatinization

None

50-55, fifty to fifty-five minutes for gelatinization

None

55-60, fifty-five to sixty minutes for gelatinization

Zea Mays var. everta (Golden Queen)
Zea Mays var. everta (White Rice)
Zea Mays var. indurata (N. Dakota)
Zea Mays var. indurata (C.'s Early)
Zea Mays var. indentata (E'y L'g)
Zea Mays var. saccharata (S.'s E'n)
Zea Mays var. saccharata (B. Mex.)
Zea Mays var. saccharata (G. B'm)
Andropogon Sorghum var. (W. K. Corn)
Andropogon Sorghum var. (Y. B. Sorgh.)
Andropogon Sorghum var. (Shallu)
Panicum Crus-galli var.
Oryza sativa var.
Secale cereale var. (Mammoth Winter)
Secale cereale var. (Spring)
Hordeum sativum var. (Champion)
Avena sativa var. (Clydesdale)
Arrhenatherum elatius var.
Vicia sativa
Vicia fulgens
Phaseolus vulgaris var. (Red K. Bean)
Phaseolus lunatus var. (H.'s B. Lima)
Dolichos Lablab
Mucuna pruriens
Lens esculenta
Lathyrus odoratus var. Shahzada
Lathyrus magellanicus var. albus
Pisum sativum var. (Elec. E. Early)
Pisum sativum var. (Mam. G. Seeded)
Pisum sativum var. (L. W. Marrow-fat)
Wistaria chinensis
Polygonum Fagopyrum var. (American)
Polygonum Fagopyrum var. (Japanese)
Quercus Muhlenbergii
Quercus rubra
Quercus texana
Arum palaestinum
Arum cornutum
Arum italicum
Arisaema triphyllum
Dracunculus vulgaris
Richardia Elliotiana
Richardia africana
Richardia albo-maculata
Dieffenbachia seg. var. nob. (pith)
Dieffenbachia seg. var. nob. (cort.)
Dieffenbachia seg. var. mac. (pith)
Dieffenbachia seg. var. mac. (cort.)
Dieffenbachia seg. var. irror. (pith)
Dieffenbachia seg. var. irror. (cort.)
Dieffenbachia illustris (pith)
Dieffenbachia illustris (cortex)
Hyacinthus orientalis var. albus (White)
Hyacinthus orientalis var. albulus (Italian)
Muscari botryoides
Muscari paradoxum
Muscari micranthum
Muscari conicum
Muscari commutatum
Muscari racemosum
Muscari compactum
Muscari comosum
Brodiaea peduncularis
Brodiaea ixioides var. splendens
Brodiaea candida
Brodiaea lactea
Brodiaea laxa
Brodiaea coccinea
Brodiaea grandiflora
Brodiaea californica
Brodiaea Purdyi
Brodiaea stellaris
Brodiaea capitata
Brodiaea congesta
Triteleia uniflora
Lachenalia pendula
Lachenalia tricolor var. luteola
Colchicum Parkinsoni
Hippeastrum vittatum
Hippeastrum equestre
Hippeastrum aulicum var. robustum
Vallota purpurea
Crinum fimbriatulum
Crinum americanum
Zephyranthes candida
Zephyranthes rosea
Sprekelia formosissima
Haemanthus Katherinae
Hymenocallis undulata
Hymenocallis calathina
Leucojum vernum
Leucojum aestivum
Galanthus nivalis
Galanthus Elwesii
Sternbergia lutea
Narcissus Horsfieldii
Narcissus maximus
Narcissus Bulbocodium
Narcissus Bulbocodium var. conspicuus
Narcissus Bulbocodium var. monophyllus
Narcissus incomparabilis

Narcissus odorus
Narcissus poeticus
Narcissus biflorus
Narcissus Jonquilla
Narcissus Jonquilla var. rugulosus
Narcissus Jonquilla var. Campernelli rug.
Narcissus tazetta var. orientalis
Tacca pinnatifida
Iris florentina
Iris pallida speciosa
Iris pumila var. cyanea
Iris Bismarckiana
Iris iberica
Iris xiphium var. Grand Tresorier
Iris xiphium var. Wilhelmine
Iris xiphium var. lusitanica
Iris tingitana
Moraea tristis
Homeria collina
Gladiolus byzantinus
Gladiolus primulinus
Gladiolus cardinalis (Blushing Bride)
Gladiolus floribundus
Watsonia humilis
Watsonia iridifolia var. O'Brieni
Watsonia Meriana
Tritonia crocata
Tritonia crocata var. lilacina
Tritonia securigera
Tritonia Pottsii
Tritonia crocosmaeflora
Freesia refracta var. alba
Freesia refracta var. Leichtlinii
Antholyza crocosmoides
Antholyza paniculata
Crocus versicolor (Cloth of Silver)
Crocus var. (Baron von Brunow)
Romulea rosea var. speciosa
Cypella Herberti
Marica Herberti
Gelasine azurea
Nymphaea marliacea var. albida
Nymphaea Gladstoniana
Batatas edulis
Cycas revoluta
Zamia integrifolia

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